A PRACTICAL TREATISE

ON THE

WORKING AND VENTILATION

OF

COAL MINES;

WITH SUGGESTIONS FOR IMPROVEMENTS IN

MINING.

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ERRATA.

Page 107, line 18, for *done*, read *be done*.

CHAPTER I.

INTRODUCTORY REMARKS.

MY object in publishing the following pages is to disseminate among Underground Colliery Managers, and others connected with practical mining, information upon the different modes of Working, and the most approved systems of Ventilating Coal Mines in this country.

The want of a more extensive and general knowledge of mining among practical men, has from time to time been forcibly brought under my notice during the last few years, by circumstances arising out of the discharge of my duties as a Colliery Viewer; and for some time the idea has suggested itself of publishing a Work on the subject, which other engagements have, until now, prevented the completion of.

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of Underground Colliery Managers; it will be my endeavour to adapt them to the capacities of persons holding such, or similar situations.

In this Work I shall apply the term "*Underground Manager*" to those persons who, in their respective localities, are known as Under-viewers, Overmen, Bottom-stewards, Underlookers, Undergound-bailiffs, and the like.

During my professional experience of the past twelve years, partly in the Northern Coal Field, and partly in the Yorkshire and Lancashire Coal Fields, as well as in occasional visits made to other mining districts, my duties have almost daily brought me into contact with Underground Managers, amongst whom I have met with many skillful and expert pit men. But I have had occasion to observe that their skill and expertness were confined to the particular methods of working practised in their own localities, where, in a great many instances, the modes of working in other districts might be pursued with considerable advantage.

In every coal district, strong prejudices are entertained by practical men in favor of the methods or plans of working mines practised in the locality in which they reside. We cannot be surprised at this; since, in general, Underground Managers have been associated from early youth with a particular system of working, to which they have become so habituated, that they are unwilling to entertain, and still less inclined to

adopt, any other. The North Country pit men can only talk of the bord and pillar workings—the Yorkshire pit men, of the narrow bords and banks—the Derbyshire pit men, and pit men from some of the Southern Coal Fields, of the long wall or long work. I am anxious to see Underground Managers made thoroughly acquainted with all the various modes of working mines, so that they may be competent to carry out that method of working which is best adapted to the condition in which a seam is placed.

There is much practical detail that I have not noticed in this Work. I take it for granted that persons in the office of Underground Managers, already possess a knowledge of practical detail in colliery management. If they do not, they have no business to fill such office.

I have directed attention to the use of those instruments which indicate changes in the atmosphere that affect the safety of mines, by causing bodies of gas to be liberated from goaves and blowers. Some other instruments which are useful to the miner are also noticed.

I have appended to this Work such rules and regulations as ought to be observed by workmen in, and about Collieries, and which direct the attention of Underground Managers to those means which should be used to preserve the health and lives of their men; also some remarks on the *Safety Lamp,* together with rules to be observed for the proper use of it, in mines which yield fire damp. These regulations for the Safety Lamp were

first introduced by my friend Edward Potter, Esq., of South Hetton, Cramlington, and other collieries in the North of England, where they have been generally adopted. I have also added an address to Underground Managers, on their duties, and drawn their attention to some neglected points of practical detail.

The remarks on the state in which gas exists in mines by T. J. Taylor, Esq., of Earsdon, Newcastle-upon-Tyne, noticed in the recent Report of Professor Phillips on the Ventilation of Mines, should be attentively read by practical men. It is essential that they should possess a knowledge of the state in which gas exists in mines; as the means used to preserve the safety of fiery seams at moderate depths, where the gas exists in a feeble state of tension, and flows regularly from the seams, strata, and goaves, when not disturbed by atmospheric influences, will not be effective in those deep seams, where the gas is found of greater tension, and accumulated in natural cavities, in, and around the seams, whence it is liable to be suddenly liberated in large bodies, as the workings approach its receptacles.

Several valuable Reports on Mines and Explosions in Collieries, by eminent scientific men of the present day, have, at different periods been published, containing much that is instructive and interesting to the practical man. Among these are the following:—

Reports on Gases and Explosions in Collieries, by De la Beche, Lyon Playfair, and Warrington Smyth, 1847.

Report on the Explosion at Darley Main Colliery, near Barnsley, by Messrs. Tremenheere, and Warrington Smyth, 1849.

The Report of the South Shields Committee in 1843, on the Cause of Accidents in Coal Mines, contains some useful information. The Report of the Evidence given before the House of Commons in 1835, on Accidents in Mines, together with the Report of Evidence on the Ventilation of Mines before the House of Lords in 1849, contains much that every practical man should know.

The recent Reports of Professor Phillips and Mr. Blackwell, on the Ventilation of Mines, should be attentively read by practical men. They contain much information that would prove eminently useful. I am indebted to these Reports for some valuable statistics upon the subject to which they refer.

The recent Act for Colliery Inspection, if its provisions shall be properly carried out, will tend to effect many desirable reforms, by the introduction of better regulations, improved arrangements and ventilation in several districts; and no one will rejoice more than myself to see these improvements carried into effect. Should my humble endeavours prove instrumental in imparting to Underground Managers a more extended knowledge of mining, than that which they may have obtained in their several localities, I feel persuaded that the interests, both of the proprietors and the employed, will be materially promoted.

The deeper Winnings or Collieries of the present day require to be opened on a more extensive scale than those of past times, in order to raise quantities somewhat commensurate with the expenditure: the increased depth, the greater extent of operations, and greater activity in working, tend to increase the dangers of mining, and the responsibility of Underground Managers. To meet these increased exigencies, it is obvious that Underground Managers should possess greater intelligence, and more extensive mining knowledge—requirements not only necessary for the management of our deep collieries, but also for the better management of collieries in general.

It is to be regretted that in past times the education of the Working Miner has been greatly neglected. The consequences of this neglect have been made so apparent in the disastrous occurrences in mines, ascribable to causes which the moral and intellectual training of the Miner might have prevented, as to have induced a general feeling amongst persons interested in the management of collieries that steps should be taken to correct this evil. It becomes manifestly the duty of Proprietors for their own sake, no less than for that of the men in their employ, if they have not the means of imitating the laudable example set in many parts of the country, of providing Schools for the accommodation of their work people and of others in their neighbourhood, where public instruction is not sufficiently afforded, to

promote to the utmost of their power such means as exist in their localities for the furtherance of the education of the working classes. The establishment and encouragement of Public Schools, of Reading Rooms and Lending Libraries, the erection of a better class of Abodes, and the exertion of a superintending care over, and the taking a kindly interest in, the welfare of the Working Miner and his family, with much that need scarcely be here particularized, would tend to elevate the character of the Miner, to make him exchange his, at present too often reckless and improvident habits, for such as would evince a more just sense of his duty to his employer and himself; and finally, and above all, by enabling him to exert a more enlarged comprehension of the sources of danger connected with his employment, and of the instrumentality of the means to be used in repressing it, induce him to act with the unceasing caution indispensably necessary to avert the sacrifice of life.

CHAPTER II.

Remarks on the Working of Coal Mines.

In working a Colliery the Owner is anxious to raise the greatest proportion of round, or large description of coal, at the lowest cost, consistently with the proper management of the mine. Large coal realizes a better price, than the small kind of the same quality. The labour of the miner, and the method of working a mine, have an important bearing on the yield of large or round coal, and to this consideration I would here direct the attention of Underground Managers.

There is in all coal districts, it must be admitted, a great want of improvement in the skill and labour of the miner, entailing a considerable yearly loss in regard to the yield of large coal, and which might be avoided by care and diligence on the part of Underground Managers. In the course of my experience I have had occasion to observe that this loss has generally been prevented where the men have been properly trained. It is to be regretted that Underground Managers do not bestow more attention to the training of their Pit Men, so as to increase the number of good workmen. With the view to raise the working character of the Miner, and instruct him better in the discharge of his

duties, I have noticed the means to be pursued, in my advice to Underground Managers in Chapter 19 of this Work.

The conditions in which seams are placed, with regard to the roof, floor, and natural formation, and the distance of workable seams above or below, are so various, that it is impossible for all to be profitably worked after the same plan. The method of working should, therefore, be adapted to circumstances; and it has to a great extent, with reference to the quality of the coal, a direct influence on its commercial value, one system of working producing from thirty to forty per cent, or about one-third more of round coal than another, the round coal having the preference in the market. One seam will be worked to the greatest advantage by the bord and pillar, (See Plans 2 and 3); another by long work, (See Plan 4); another by narrow bords and by long work, (See Plans 12 and 13); another by narrow ends, and the pillars got in jenkings, ribs, or faces, six to eight yards wide, and having one end loose to the goaf or where the coal is entirely excavated, (See Plans 14, 15 and 16).

The older explored coal fields have each their peculiar modes of working, modified to suit the circumstances and conditions of the roofs and floors of the seams. In the more recently explored coal fields modifications of the methods of working mines practised in the old working coal fields are commonly adopted.

Bord and Pillar or Post and Stall workings are peculiar to the Newcastle or Northern Coal Field, and in that district the arrangement of the workings, the principle of ventilation, and the good discipline established in the well regulated collieries should be more generally imitated by the collieries in other coal fields.

The Long Wall or Long Work mode of working is peculiar to the Derbyshire and some of the Southern Coal Fields. By this method the whole of the coal is got at one operation, by working in banks of various widths towards the rise from the shaft, and maintaining roads through the goaf or broken by building strong stone continuous pillars with the fallen roof: also by driving narrow bords to the extremity, and working the coal towards the shaft or homewards by long work, leaving the goaf behind. In this latter case no roads are maintained through the goaf.

Wide Work is a mode of working peculiar to the Yorkshire Coal Field; a series of bords from seven to ten yards wide, separated by a pillar of coal one yard thick, (and not got out) form a bank, which is worked towards the rise of the mine or from home, pillars of coal twenty to forty yards wide being left between two such banks, and worked towards the shaft or homewards, after the banks on each side are driven the determined distance.

It has been, and is still the practice in many mining districts, in working seams by the bord and pillar, to leave large areas of pillars standing until a considerable

portion of the Royalty is excavated in bords or drifts. Long standing pillars do not yield so great a proportion of large coal as those which are more expeditiously worked, and in many instances I have known pillars of long standing to be entirely lost. The exposure of some roofs to the atmosphere for a length of time in the excavated bords, causes a general settling of the roof on the pillars, and crushes them. The loss by crushed pillars is great, and is well known to be so by those who have experienced it.

A greatly improved method of working mines has now for some time been practised by the Viewers in the Newcastle Coal Field. The coal is got in districts, panels or divisions, and whole coal and pillars are worked simultaneously in the same district or division, (See Plan 2). This arrangement of the workings is adapted to a flat seam, and reduces to as great an extent as possible, consistently with the proper working of the mine, the area standing in pillars—these pillars remaining ungot from two to four months, according to the length between the bord or drift faces, and the faces of the working pillars.

The arrangement of the workings in Plan 3, is adapted for working seams which have an inclination in the direction of bord-ways course, in districts, panels or divisions. Seams with an inclination cannot have whole coal and pillars worked simultaneously in the same district as cheaply as flat seams: the increased cost

of conveying the coal up bank, or up the rise of the mine from the faces of the pillars to the head-ways or end, along which it is taken to the main-roads would be considerable, and the conveyance would be impracticable in steep seams.

In the system of working shewn on Plan 3, a district or division of the seam is excavated in bords or drifts before the pillars are touched. The operation of removing the pillars begins at the rise part of a district or division. Advantage is taken of the inclination of the seam in working both bords and pillars, to convey the coal by mechanical means from the panel to the main-road. When Incline or Engine-planes are used in a mine, a sufficient width for a travelling-road should be left clear of the passing waggons or tubs.

Plan 13 shews an arrangement of the workings to get a seam with a tender roof, in districts or divisions, by narrow bords (in pairs) and long work: this arrangement affects the principle of Ventilation, shewn on Plan 12, but does not render any alteration in the working of the mine necessary, except as regards a little more preparation being required, before the getting of the pillars commences. The same may be said of Plans 15 and 16.

In the course of my experience, I have worked mines by the various modes treated upon in this Work, and I have invariably found that the produce of large or

round coal has been the greatest by working long work wherever circumstances were favorable. Many are of the opinion that deep seams cannot be worked with advantage by long work. *The deep Seam at Monkwearmouth Colliery, Durham,* 1800 *feet below the surface,* is however now successfully worked by this plan, and is producing a considerably greater yield of large or round coal, than is obtained by working bord and pillar. A moderately strong seam, at any depth from the surface, may be got by long work, if the roof is suitable for building the necessary packs or walls through the goaf, and less injury is done to upper seams, than by other methods of working, as the packs or walls through the goaf cause large areas of the roof to settle gradually. This method of working is not favorable for a tender seam having a heavy roof, as the weight on the bank face in such cases crushes the coal.

If a mine is first cut out to the boundaries, and then worked towards the shaft, leaving the goaf entirely behind, less coal will be crushed, and a smaller cost incurred in maintaining roads than by getting the coal from the shaft towards the boundaries. This method of working a mine may be pursued in a colliery of limited extent, as only a short period will thus be required to open the mine; but in an extensive Royalty, where a mine has to be got with a pair of shafts, the necessary preparations will obstruct the vigorous working of it for some years, involve a large outlay,

loss of interest on capital, and for the time delay a return of profits on the mine. If the getting of an extensive Royalty is begun at the shaft and continued towards the extremities, the necessary workings to open out the mine to the boundaries can be pushed forward at the same time. By working the mine after this method, under judicious management, whatever loss may be sustained by the coal being crushed, and by the extra cost of maintaining the roads, will be more than compensated for by an earlier return on the outlay.

When the mode of working a seam is determined upon, a plan of operation should be laid down, with an arrangement of the workings, suited to carrying out the best system of Ventilation. The shafts should be well supported by leaving sufficient solid coal around them. The roads of the mine should also be protected by strong pillars of coal, proportioned to the depth of the seam below the surface. When these pillars are left of insufficient strength, and the coal is got around them, the sinking of the roof crushes them, and also damages the roads, whereby a considerable addition is made to the expenses of the mine. When at length the pillars are got, they yield but a small proportion of round coal, and much beside of the coal is lost in the mine through the broken state of the roof, which requires a considerably increased quantity of timber to support it during the working of the pillars.

The workings should be systematically carried forward,

and the workmen, under no circumstances, allowed to drive places in the mine without proper directions being given; order and regularity being no less essential to the safety of a mine, than to the economical and profitable working of it.

That haste, which is common among inexperienced adventurers in the coal trade, to raise large quantities of coal, in an incredibly short time after the shafts are sunk, cannot be too strongly condemned: such persons cannot see why they should not at once commence raising large quantities, and think that others are supine who do not, as soon as the shafts are sunk, begin a wholesale raising of coal. The experienced coal owner or manager is however aware that there is some preparation absolutely necessary, before this can be done with propriety. This hasty wholesale raising of coal before the necessary preparations are made, is frequently attended with disastrous results.

There is no difficulty in working a seam systematically, and ventilating it on the best principles, when it is uninterrupted with Dykes, Throws, or Faults; and it is obvious that any seam may be worked in the manner here described with much less anxiety and care, than one worked without plan, order, or system. Where Dykes, Throws, or Faults are numerous in a seam, they offer great obstacles to the carrying out a good system of ventilation, and the resources of a Manager may be frequently taxed in working such seams; but

let him be assured that extraordinary difficulties may be overcome by a plan concerted with care, aided by such means as practical experience and sound judgment may suggest.

In some mining districts the Proprietor lets the working of his mines to a Contractor (in Staffordshire called a Butty), who provides all labor to raise the coal and to maintain the mine in a workable state. The Contractor again sub-lets the different branches of labor to the workmen. This way of letting mines operates to a great extent prejudicially to the introduction of good ventilation and discipline; almost every man's object being, under such circumstances, to make the most of his bargain, he attends to such of his duties as bring him a return for his labour, until urgent necessity requires the contrary, and thus, provisions which are necessary for the safety and welfare of the mine are neglected. I admit there may be Contractors who feel the responsibility that rests upon them, and provide not only good ventilation, but conduct the mine under as good regulations as circumstances allow. But the practice being bad, the sooner it is abolished the better, and in its place an approved system of management introduced, whereby the mines may be placed on a footing more secure from accidents, and the produce be raised with greater economy.

CHAPTER III.

REMARKS ON THE VENTILATION OF MINES.

THE extensive Winnings or Collieries of the Newcastle Coal Field, and the large quantities of gas met with in many of the seams, require a powerful and well organized system of ventilation, and an effective discipline, to preserve the Mines in a state of safety; and in no other coal field is the ventilation and discipline of mines carried to greater perfection. The deep collieries of this, and of other coal fields, are liable to sudden eruptions of highly compressed gas, which exists in cavities in, and around, the seams, and bursts into the mine in large quantities, as the workings approach its receptacles, the most powerful ventilation being found inadequate to dilute sufficiently these outbursts of gas so as to render them inexplosive. The following particulars of some discharges of gas shew the high state of tension in which it exists, and also the large quantities suddenly given off.

Two sudden outbursts of gas which took place at Walker Colliery, near Newcastle-on-Tyne (in a seam 960 feet deep), as related by Mr. Clarke, Viewer, are recorded in the Reports of Sir H. De la Beche, Dr. Lyon Playfair, and Mr. Warrington Smyth, on Gases

and Explosions in Collieries; and also in the recent Report of Professor Phillips, on the Ventilation of Mines. The first took place on the 13th of November, 1846, when approaching a slip dyke or small fault, with a pair of drifts. A mass of coal 8 feet long, 4 feet wide and nearly 6 feet high (about 11 tons in weight) was forced from the bed, and a large discharge of gas ensued. Two men were working with lamps in the drift in which the discharge took place; one of the lamps was put out, the other was partially covered with the fall of coal but continued to burn until it was taken from under the coal, and the wick was drawn down. The two men then hastened to warn the rest of the men in the pit, extinguishing the lamps as they went along, and finally retired to the shaft. (The steps taken by the men on this occasion were according to the rules of the Colliery.) About 41,681 cubic feet of the air-ways were observed to be foul, or in an explosive state. After fifteen to twenty minutes had elapsed, there were no longer traces of fire damp; the air moved in that part of the mine, where the outburst took place, at the rate of 6½ feet per second, and the quantity which passed in one minute was 10,483 cubic feet.

A second discharge from another point of the same slip dyke took place on the 10th December, 1846. The dyke was in this instance cautiously approached by bore-holes kept ahead of the face of the drifts, the last bore-hole having not only reached, but passed through

the dyke or fault into the coal beyond; no discharge of gas ensued even where the Colliers had excavated coal beyond (on the rise of) the dyke, until a portion of the roof was taken down; then the danty or inferior coal was displaced above where the bore-hole passed, a violent noise was heard like the blowing off of steam, and a heavy discharge of gas took place which fouled the air-courses for 641 yards in length, and an area of 86,306 cubic feet. At 400 yards from the point of efflux, a deputy met the foul air, saw his lamp fire, and drew down the wick; the gas continued to burn in the lamp for ten minutes, making it red hot, and then went out. At 641 yards from its source, the gas was met by four men and boys who immersed their ignited lamps in water. The explosive atmosphere, though not observed farther, probably extended farther. The air was circulating at the rate of 5½ feet in a second, and the quantity circulated was about 16,000 cubic feet in a minute. After twelve to fifteen minutes had elapsed, there was no longer any appearance of gas, except near the point of issue of the blowers, where it came off warmer than the air. The Davy Lamp which, on these occasions, saved the mine from explosion, has been used exclusively in Walker Colliery since the accident in 1817.

In sinking two shafts at this colliery, the extraordinary tension force which the fire damp possesses in its underground reservoirs was most strikingly shewn. In both cases a considerable quantity of solid freestone

was moved up, and immense discharges of fire damp took place.

Professor Phillips, in his recent Report on Mines, mentions another instance of a discharge of gas, which occurred at Haswell Colliery, Durham, the particulars of which were communicated by T. J. Taylor, Esq. of Earsdon, a gentleman whom I have before referred to. The discharge took place at the face of a pair of exploring drifts, through which nearly 10,000 cubic feet of air were passing per minute, with a velocity of 4.39 feet per second, and through a sectional area of 37 square feet. Safety Lamps were used at the face. While the Hewer was working in the usual manner in the back drift, he heard a noise, and immediately retreated to the stenting or opening next the drift face; the sound being like that of falling water, and occasioned by the rushing out of the gas at the face. The air which circulated through these drifts having, as the phrase is, *nothing to do*, was employed after passing through them, in ventilating a district farther out by or nearer the shaft, where the men worked with candles. The deputy of the way immediately ran to warn these men to extinguish their lights; he then returned and went through a door leading to the back-drift, 310 yards from the face, where with his safety lamp he found the air-course foul from top to bottom. With much prudence he kept this door open; and as the greater portion of the air current then passed by the shortest

run, the progress of the mass of fiery atmosphere was not only thus nearly stopped (technically laid dead), but the current passing through the door mixed with, and diluted it (the source being now exhausted) below the firing point. In less than half an hour not a trace of gas was to be found, either on the face of the drifts or in the district.

Mr. Taylor estimates the volume of gas thus suddenly poured forth at 3,000 or 4,000 cubic feet, and the mass which it rendered foul or inflammable, 35,000 cubic feet.

This quantity slowly delivered would have been easily mastered and rendered innocuous or inexplosive by the current of 4.39 feet of air passing through the drifts in a second; but coming off in one outburst, it would not have been reduced below a firing point by the strongest current which could by any means have been forced through the drift, but must have been borne along, carrying danger with it through all its courses. How valuable the safety lamp appears under such circumstances, and how well was it seconded by the exertions of the man in charge of the district. Mr. Taylor very justly observes that sufficient gas was thus given off to account for the heaviest explosions which have occurred in the North of England, that one unprotected light would have caused such an explosion, and such lights there were on the course of the inflammable air. Fortunately they were extinguished in time; and we have an instructive proof of the danger

of deviating from the established principle, that air which has ventilated drifts or districts worked with lamps should never be allowed to pass through those parts of the mine where naked lights are employed.

Mr. Gilroy, Viewer for Messrs. W. H. Brancker & Co., Owners of the Orrell and Bispham Collieries, Wigan, Lancashire, has had several strong blowers and sudden outbursts of gas at the first mentioned colliery. The following are some particulars of a strong blower met with in the latter end of 1849. The seam is here 900 feet deep, and called the Cannel Seam. At the distance of 80 yards from the shaft, and shortly after the seam was opened, a pair of head-ways or ends (through which 6,000 cubic feet of air circulated per minute) met with a 16 feet down-throw, which was cut 6 feet into, when two tons of mine and stone were forced from the face, and a large discharge of gas took place from a blower which fouled 40,000 cubic feet in about twelve minutes. The Furnace for ventilation was placed in a seam above the Cannel, and was connected with the shaft by an inclined drift several yards in length. Not less than 4,000 or 5,000 cubic feet of gas must have been given off during the first twelve minutes after the outburst; and so strong was the blower, that the face of the places could not be reached with safety by the Davy lamp for eight days. The Davy lamp is regularly used here. I may add, that this colliery is one of the best ventilated in the district and conducted under good regulations.

Several instances of less powerful outbursts have come under my immediate observation: those I have noticed will sufficiently manifest how formidable such casualties are. They tend moreover to shew the imperative necessity of good and efficient ventilation, and also of the exclusive use of the safety lamp, in mines exposed to such casualties.

The *Furnace* is almost universally employed for ventilating purposes in the Coal Fields of the North of England, and other districts; it is simple, easily managed, expansive in its operation, and after the furnace is extinguished, the heat of a good up-cast shaft affords a considerable ventilating power for many days. Some Viewers use a furnace with a high arch over the fire, others with a low arch. I have found the furnace with a low arch and a thin fire, the most effective.

In very fiery mines it is dangerous to pass some of the returns over the furnace; to avoid this, drifts are formed which deliver the explosive returns into the up-cast shaft, and are so arranged as to prevent the returning air from coming into contact with the fire: good ventilation will supersede the use of gas-drifts, except in cases of sudden outbursts of gas.

In such mines as those last mentioned, the furnace should be supplied with a scale of fresh air taken direct from the intake air course.

The furnace will circulate a large quantity of air through a mine when the air is judiciously distributed

and capacious air-ways are driven. Professor Phillips states in his Report before alluded to, that at Hetton Colliery (which is one of the most extensive in the North of England, and one of the large collieries under the able management of Nicholas Wood, Esq.), 169,000 cubic feet of air are circulated through the mine per minute by means of three Furnaces, and one up-cast shaft 14 feet in diameter and 900 feet deep. Eleven districts in the mine, each with an average run of 4½ miles, are ventilated by these means.

At Haswell Colliery, a very extensive Winning in the County of Durham, 94,000 cubic feet of air are circulated through the mine by means of the furnace, and one up-cast shaft 8 feet 6 inches in diameter and more than 900 feet deep; the down-cast shaft being about 12 feet 6 inches in diameter.

It may here be well to observe that there is a practice in many districts of smothering the furnace during the night with small coal, in order to save the cost of attendance; in such cases the fire is broken up in the morning, either shortly before or when the workmen descend, and thus the ventilation does not get into an active state until some time after the men begin work. This intermitting ventilation is objectionable and dangerous in fiery seams, as a regular ventilation should be kept up night and day. (For various statistics respecting ventilation by the Furnace, see the evidence of several Viewers, given before the Lords'

Committee, and detailed in their Report on the Ventilation of Mines, 1849.)

The use of *High-pressure Steam* for Ventilation has been recently introduced into our collieries, and is the invention of Goldsworthy Gurney, Esq. When the flow of steam from the jets ceases, a more sudden cessation of ventilation takes place than after the extinguishing of a furnace, as there is little warmth in the shaft to create a current. In fiery seams with dangerous returns, the steam-jet may however be used with some advantage; no separate foul air drifts are required, as all returns can be conducted in a body to the up-cast shaft.

One great advantage in the use of high-pressure steam for ventilation purposes, is the facility with which the circulation of air can at any time be augmented. If the steam be applied at the bottom of the shaft, it should be in connection with heat, otherwise the effect will be reduced by its condensation. If the jets are applied near the top of the shaft, the effect is limited, compared with that produced by their application at the bottom.

Seaton Delaval Colliery, in the North of England (and one of the collieries under the management of Thomas E. Forster, Esq., of Newcastle-upon-Tyne, a Viewer of great experience), is ventilated by the use of high-pressure steam in connection with the heat from the Boiler Fires. 86,000 cubic feet of air are circulated

through the mine per minute, one up-cast shaft of 8 feet diameter and 600 feet deep is employed in the ventilation of it, twenty-five jets of steam (each jet being three-eighths of an inch diameter) are placed at the bottom of the shaft, and steam is used at a pressure of 33lbs. to the square inch. Previously to the use of steam for ventilation at Seaton Delaval Colliery, two Furnaces, with 50 square feet of fire surface each, and two up-cast shafts, one 9 feet in diameter, and the other 8 feet in diameter, were employed, when only 53,000 cubic feet of air were circulated through the mine per minute. After more than two years' experience of the use of high-pressure steam for ventilation, Mr. Forster finds it more effectual and more economical at Seaton Delaval, than ventilation with the furnace. (For further particulars respecting ventilation by high-pressure steam, see Mr. Gurney's, Mr. Forster's, Mr. Wood's, Mr. Taylor's, and Mr. Elliot's Evidence before the Lords' Committee on the Ventilation of Mines, in 1849.)

A *Fall of Water* is occasionally used as a ventilating power; in this case the air is forced into and through the mine by the momentum of the falling water. Ventilation by forcing the air through a mine, by whatsoever means, is objectionable for permanent ventilation, because only limited quantities can be forced through it, and it occasions an increased pressure throughout the mine, and adds to the accumulation of

gas in the goaves and crevices, which is one evil that is sought to be remedied.

Ventilating Machines are likewise objectionable for permanent ventilating power, on account of their liability to derangement and consequent stoppage of the ventilation.

Whatever may be the means for obtaining ventilation, ample provision for an abundant supply above the usual requirements should be made; so that on extraordinary occasions all, or any, of the districts of the mine can have an increased supply of air.

The quantity of air required to ventilate a mine will depend on the extent of the workings, the thickness of the seam, the quantity of gas in the mine, and the number of Hewers or Colliers employed. Professor Phillips in his Report states, that in the most fiery seams in the North (the heights of which vary from 4 to 6 feet), an average of near 600 cubic feet of air per minute is circulated through the mine for each Collier employed; and that near 200 cubic feet of air per minute are circulated for each statute acre of mine. J. K. Blackwell, Esq., in his Report on the Ventilation of Mines, states, that from 250 to 500 cubic feet of air per minute should be circulated through the mine for each Collier employed, according to the fiery state and extent of the mine; and in my practice I have circulated quantities varying from 100 to 500 cubic feet per minute for each Collier. The circulation

necessary for a mine in ordinary times should be regularly measured or guaged as a guide to maintain a ventilation proportionate to the extension of the workings.

A mine with a small circulation of air properly distributed may be better ventilated than one with a large circulation injudiciously applied. We are not therefore to infer that a mine is well ventilated because it has a large circulation of air. A mine inefficiently and feebly ventilated will however be more liable to explosions with gas liberated from the goaves by atmospheric influences, than one with an efficient and powerful ventilation. In the former case, the small quantity of air passing through the mine, may only form an explosive compound with gas liberated from the goaves, as Carbureted Hydrogen Gas requires sixteen times its bulk of atmospheric air to render it inexplosive.

The workings of a mine may be tolerably well ventilated, and have every appearance of being safe and free from gas when the day's work is concluded. Reliance should not however be placed upon this, but a careful examination of the mine should be made the following morning, previously to the descent of the workmen, as a change in the pressure of the atmosphere may take place during the night, and thus cause the gas in the goaves to expand, and those parts of the mine, which shewed the night before no indications of gas, might, after such a change, be dangerous. It is possible that some of the

explosions which have taken place in well ventilated mines, at the time the men were resuming work in the morning, may have been preceded by a change of pressure in the atmosphere; and had the Underground Manager in these cases observed the changes by the Barometer, disastrous consequences might have been prevented.

Observations, either by Instruments or other means to detect atmospheric changes which cause either the explosive, or carbonic acid, gas to be liberated from the goaves into the air courses, are more required in ill ventilated than in well ventilated mines. This circumstance however should by no means supersede their use in well ventilated mines.

Wooden Air Pipes are in some instances substituted either for an up-cast or down-cast shaft in the ventilation of mines; such means for the permanent ventilation of a mine are objectionable under any circumstances, as the quantity of air that can be circulated through a mine by their use, (whether employed for up-cast or down-cast), is very limited; in addition to this, the pipes may be very easily destroyed and the ventilation thus be suspended. A Proprietor having regard for the health and lives of those employed in his mine, would not have recourse to such *frail* and *inadequate* means for the ventilation of the workings of his colliery. The practice of dividing a shaft either with a wooden, stone, brick, or other partition, for the purposes of ventilation,

is also open to the same objection as the use of Wooden Air-pipes.

When a seam is won or opened by a pair of shafts near together, a partition of strata should be left between them, sufficiently strong to resist the shock of an explosion; and the shafts should likewise be cased with bricks set dry or with hydraulic lime, or be cased with timber; casing with bricks should especially be done in deep collieries. The longer period deep shafts are in use, and the greater extent of their surface exposed to the atmosphere than in shallow shafts, increases the liability to accidents in ascending and descending when the shaft sides are unprotected.

Where a powerful ventilation is required, and the furnace is employed, it is advisable to use a shaft exclusively for the purpose; as the high temperature necessary to circulate a large body of air through a mine destroys the hempen ropes, and is injurious to the wire ropes used in drawing coal. Under no circumstances should the Engine shaft, or the shaft used for pumping water, be employed for an up-cast, when the ventilation is produced by the furnace, as the wet and cool state of such shafts reduces the ventilation to a considerable extent.

If the up-cast and down-cast shafts are sunk either at each extremity of the Royalty, or at some considerable distance apart, in the event of an explosion destroying the air-ways, a current of fresh air will pass through the

mine from one shaft to the other, and preserve the lives of such of the workmen as can gain access to it. Such an arrangement of the shafts is not always practicable. Local and other circumstances connected with surface operations and conveniences will frequently determine the position of the shafts.

It is the opinion of some persons that when the Furnace is used, the up-cast shaft should have a larger area than the down-cast, in order to afford room for the expansion of the air, and to produce a greater ventilation. A temperature in the up-cast of 60° above the temperature in the down-cast shaft will only cause an expansion in the air of about one eighth, and require a very small portion of the effect of the Furnace, to overcome the resistance in the shaft. The power of the Furnace is exerted in drawing the air through the passages of the mine, consequently the areas of these passages have considerable influence on the amount of circulation. I have found when no alteration has been made in the Furnace and air-ways, that a reduction of the area of the up-cast to two-thirds of that of the down-cast shaft has not caused a reduction in the ventilation.

If an up-cast shaft is exclusively used for ventilation purposes, velocities from 20 to 30 feet per second can be produced by means of the furnace in good shafts after drawing the air through the workings; but if the up-cast is employed for raising coal, velocities from 8 to 12 feet per second can only be attained, without the heat

destroying the ropes and fittings of the shaft. With the use of high-pressure steam for ventilation, greater velocities than these may be obtained in either case. Hence if the up-cast is used for drawing coal, a larger size will be required than if the shaft is exclusively employed for ventilation; on the other hand if high-pressure steam is employed for ventilation, a smaller sized up-cast may be used, than if the Furnace is employed. Nevertheless I would in all cases recommend capacious up-cast shafts.

The Main Air-roads of a mine, when it is practicable, should be of such an area, that the current of the ventilation required will be slow, so as to keep down the friction (the resistance from friction increasing as the square of the velocity), and not prove inconvenient in the travelling-roads. A workman passing through a mine at an ordinary speed can carry a lighted candle against a current of air moving at the rate of from 4 to 6 feet per second; if the current move with greater speed it will be difficult to keep in naked lights; such an inconvenience however must not have any influence in keeping down the ventilation, but the lights should rather be screened or protected from the current of air.

The area of the Main Air-roads must not be reduced in the erection of crossings, nor any other contractions be made, nor anything be allowed to obstruct the free flow of the air. This requires much care if the main roads are narrow, and where falls of the roof may contract the area and seriously reduce the ventilation.

Contractions of the air-ways increase the friction, limiting the operations of the Furnace, and reducing the circulation of air. I have several times witnessed the dangerous state of mines, caused by fallen roof contracting the size of the air-ways in narrow workings, and by the tubs being left in the air-ways, both of which circumstances have considerably reduced the ventilation.

The crossings to carry return air-courses over intake or fresh air-courses should be strong brick arching, or be formed in the strata above the coal, if it be sufficiently strong; otherwise the crossing adopted by Mr. Heckells, Viewer, of Thornly Colliery, Durham (and noticed by Professor Phillips in his Report, which is accompanied with a Plan of it), may be used.

When doors are required they should be double doors, and only one should be allowed to be open at the time of passing through, and in all cases they should be so hung as to close of themselves.

The pillars between the main-roads of the mine are in many instances of insufficient strength, and only imperfectly separate the intake or fresh air from the return air. This arises from a mistaken notion of economy, in endeavouring to save the expense of cutting a few yards of narrow work in making communications between these roads; these openings or communications between the main-roads should be made of a size only sufficient for the passage of the tubs, and at as great a distance apart as circumstances admit of, and when practicable,

in addition to the brick stopping set in lime, they should be stowed tight with refuse of the mine, so that the shock of an explosion may be resisted by these partitions, and a circulation of air be thus maintained to the extremities of the mine. This course may enable the men who escape the Fire, to meet with fresh air and avoid suffocation. The force of a heavy explosion is so great that even stowed stoppings to a length of nine feet have in some cases been insufficient to resist the shock; much depends on the direction the force takes, and the extent of opened mine in the vicinity of an explosion.

If the stoppings are made strong enough to resist the shock of an explosion, crossings should likewise, if practicable, be made the same, by forming them in the solid strata above the coal; if this cannot be done, the other crossings already described must be used. Interrupted ventilation can sooner be restored, by repairing the crossings which are blown down by an explosion, than the stoppings which may be destroyed at such a time can be replaced.

I would however direct attention to the prevention of explosions by *efficient Ventilation, good Discipline, and the exercise of Vigilance* on the part of mine officials, and I am sanguine in the opinion that these calamities may yet be only historically known.

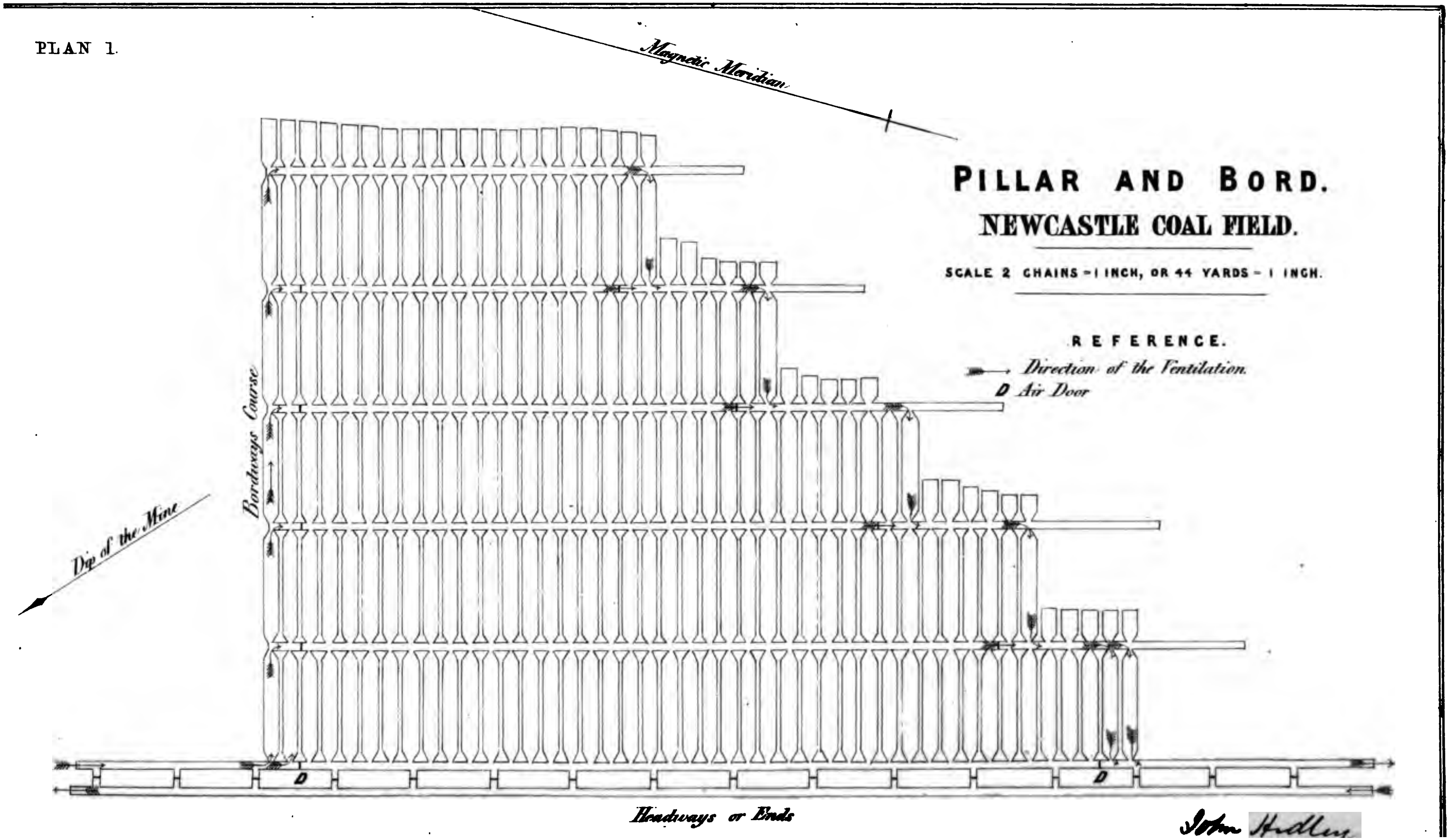
Exploring-drifts should be driven in the vicinity of old workings, with borings some distance in advance of the face of the drifts. These exploring-drifts should either

be ventilated by a separate current of air, or receive the return from a limited district of the mine; and safety lamps should be exclusively used, under proper regulations, in dangerous parts of the workings. When safety lamps are used, some neglect the ventilation. If the state of a mine requires the use of lamps, it also requires good ventilation, as the necessity for the use of the lamp implies the presence of a species of danger which good ventilation alone can remove.

Ventilation by circulating the air through the mine in one current has long been discontinued in the North, and partially so in some other Coal Fields, being found to be bad in principle and ineffective, as compared with ventilation by splitting the air. The ventilation of distant parts of the mine, in the former case, is dependent on doors placed in the main-roads, and is liable to be deranged by the tubs passing through the doors, which in their turn form a great obstruction to the passage of the tubs. Bodies of gas liberated from the goaves and blowers by atmospheric changes, and sudden outbursts of gas from the seam, will be circulated through the working parts of the mine; in addition to this, unexpected tapping of gas accumulated in old workings is, through the neglect of using proper precaution, not of unfrequent occurrence, and this gas will pass along with the air through the mine. Any impediment to the current of air affects the ventilation throughout the mine.

The most approved system of ventilation is that which is not dependent on doors placed on the main air or travelling-roads of the mine in order to circulate the air through the workings, but which makes each travelling-road a fresh air-road, and conveys the return air to the up-cast shaft without passing along any roads used by workmen. This system of ventilation can be applied to some modes of working, by getting the seam in districts or divisions, and splitting the air, each district or division having a separate supply of air controlled by a regulator. Plan 2 shews this system, and Plans 12 and 13 shew the two systems of ventilating narrow bords and long work. The Viewers in the Northern Coal Field first introduced the method of ventilation by splitting the air, and some of the Lancashire and other collieries under skillful management are also ventilated on the same principle. Splitting the air shortens the distance it has to travel, and this, together with the reduction of its velocity in each district, diminishes the friction and consequently the drag on the furnace, thereby causing the circulation of a greater body of air through the mine. The extensive collieries of this country could not be efficiently ventilated otherwise than by splitting the air.

PLAN 1.


Magnetic Meridian
PILLAR AND BORD.
NEWCASTLE COAL FIELD.
SCALE 2 CHAINS = 1 INCH, OR 44 YARDS = 1 INCH.
REFERENCE.
Direction of the Ventilation.
D Air Door
Dip of the Mine
Bordways Course
D
D
Headways or Ends
John Hedley

ORD AND PILLAR,

NEWCASTLE COAL FIELD;

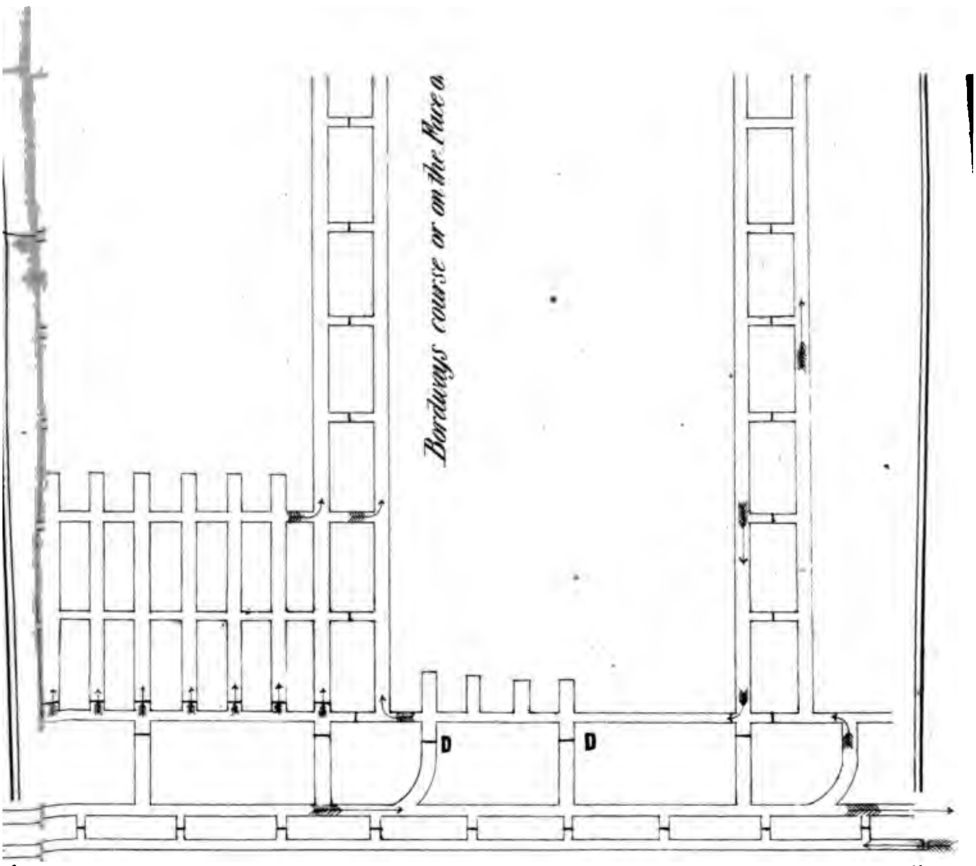
Coal and Pillars worked together, in the same district.

VENTILATION BY SPLITTING THE AIR.

SCALE 3 CHAINS = 1 INCH, OR 66 YDS = 1 INCH.

REFERENCE.

——— *Direction of the Ventilation.*



John Hedley
Wigan
Lancashire

CHAPTER IV.

Bord and Pillar Workings of the Newcastle Coal Field.

Plan 1 illustrates the method originally practised in working seams by bord and pillar. By this method as large a proportion of the mine was removed at one operation as circumstances would admit of; bords were worked, leaving pillars, which were not got out, of a strength proportioned to the depth of the seam below the surface. In late years, some of these pillars formerly left in moderately deep seams have been got. Under some circumstances shallow seams are now worked by leaving the pillars standing. If the cost of repairing the surface damage, caused by removing the whole of the coal, is greater than the value of the coal left in the mine, this mode of working is practised.

In working seams by the bord and pillar, the most approved plan practised in the North of England is that of getting the coal in districts or panels, with a strong pillar between each panel which is got out, (See Plan 2). Three capacious main-roads are driven, the middle one being the main travelling-road and fresh air-road; the two side ones return air-roads, and not used for travelling. A panel of bords or drifts is worked parallel to these

main-roads on each side; and at three or four pillars' length from the face of the bords, the process of getting the pillars is going forward, thus leaving a very limited area of the seam standing in the pillars, and only for a short period, so that the coal will be less injured by being crushed than if large areas of the mine were left in pillars for a length of time. The panel on one side of the main-roads is worked a pillar in advance of the other. The coal is brought from the bords through the doors (DD) placed in the stenting or opening next to the face of them; and the coal from the pillars is brought through the doors (DD) placed in the stenting or opening next to the face of the pillars. This arrangement of the workings is adapted for a flat seam.

Plan 3 shews an arrangement for working seams which have an inclination on the bord-ways course in districts or panels. A panel of bords or drifts is worked up to a determined distance, when the process of getting the pillars begins at the rise part of the panel, the bords or drifts in the next panel being excavated at the same time. Strong pillars are left between each panel of bords to bear the pressure caused by the sinking roof when the pillars of the adjoining panel are got out. This arrangement leaves as limited an area of the seam standing in pillars for as short a period as circumstances will allow.

If the mode of ventilation shewn in Plan 3, Part 3, is adopted, some preparation is necessary before the

working of a panel is begun: the headways or ends at the top and bottom end of the panels must be first driven, and a communication made between them, at the boundary of each panel, by a pair of bords or drifts, separated with the pillar between the panels. The coal may be conveyed from each panel by means of an inclined plane. If the seam is level along the face or headways-course, the middle bord or drift, or a side bord in the panel, may be used for the inclined plane, (See Plan 3, Parts 3 and 4). If the face is inclined, the lowest bord in the panel may be used for the incline plane, (See Plan 3, Parts 1 and 2); as two panels are here ventilated by one current of air, the coal from one will pass through the doors (DD), and no doors obstruct the passage of the tubs from the other panel.

Seams with a strong roof are worked in bords 4 to 5 yards wide, and pillars left proportioned to the depth of the seam below the surface. A strong roof and soft floor require wide pillars to be left, to prevent the heaving or lifting of the floor, which is caused by the pressure forcing pillars of inadequate strength into the floor. In the mining language of the North this is called a *Creep*. The escape of gas from the measures beneath the coal will also frequently force up the floor, an occurrence that may be prevented, to a great extent, by drilling short holes into it, in order to facilitate the escape of the gas.

There is considerable advantage in working a seam

with a tender roof and soft floor, in panels; a limited area of the seam is opened at once, and for a short time; consequently there is less destruction in the bords by the falling of the roof and heaving of the floor, and less timber required than if a large area was first worked in bords before getting out the pillars, and also less injury to the pillars, by weight upon them. The long standing pillars in some seams only yield from 30 to 40 per cent or about one-third of large coal, whilst if they were got out expeditiously they would yield 70 per cent or nearly three-fourths of large coal.

In working with wide bords, attention should be paid to the nature of the strata a distance above the seam, some seams having a thin bed of strong roof upon them with tender measures above; such a roof may stand very well in wide bords or drifts working whole coal, but when the pillars are being worked and a weight comes over the face, it will break through the thin bed of strong roof in the bords or drifts, and partially close them up some distance down from the face of the pillars; in such cases, and in the partial closing up of long standing bords, either by the falling of the roof, or heaving of the floor, the pillars have frequently to be split or jenkinged in order to get them, and this frequently entails a great loss of coal.

When it becomes necessary to split a pillar in order to get it, less coal will be crushed and lost by driving a loose jenking or a portion worked from one side of the

pillar when it is practicable, than by driving a fast jenking or a place up the middle of the pillar; nevertheless cases may arise when it is better to split the pillar up the middle.

Consideration is not generally given in regard to leaving the strength of the pillars proportioned to the depth of the seam below the surface, the consequence of which is that they get crushed, and yield a small per-centage of large or round coal, and the cost of timber in supporting the roof and of labour in maintaining roads is considerably increased. A creep moreover may take place and bury large areas of pillars. The hasty working of the mine when the shafts are first sunk also causes pillars of insufficient strength to be left, which brings on effects similar to those I have just described, and besides renders the shafts insecure or probably useless. These last consequences frequently result from a desire to gratify employers by raising large quantities of coal before it is either prudent or practicable to do so, and in many instances from ignorance as to of what strength the pillars should be.

CHAPTER V.

VENTILATION OF BORD AND PILLAR WORKINGS.

PLAN 1 shews the Ventilation of workings in shallow seams. The air circulates through the headways or end nearest the face of the bords. The freedom of shallow seams from fire damp does not require that the bord faces should in all cases be ventilated.

Plan 2 shews the system of ventilation adopted in the North, in working a seam in districts or panels. The middle road is the main travelling-road of the mine, and also the intake or fresh air-road; the two side-roads are return air-roads. No air-doors are fixed on the main-roads. Each panel or district takes its supply of air from the middle main-road, and is controlled by a regulator fixed on the return from each. When the air has ventilated the faces of the main-roads, it is conducted to the faces of the bords in each panel by means of bratticing from the headways or end next to the face, and at the bottom of the bratticing in the headways or end, a swing door or cloth is hung to allow a passage for the tubs. The air passes from the bords or whole coal workings to the faces of the pillars in the same panel, along which it sweeps and presses towards the goaf, forcing the gas from the men at the

face, and finally being sent over a part of the goaf into the return air-course, it is conveyed into the up-cast shaft without going along any of the travelling-roads of the mine. The advantage of this arrangement of the ventilation over that where the air circulates through the mine in one current is evident when bodies of gas are liberated from the goaves by atmospheric changes, or sudden outbursts take place. The main-roads between the panels can be separately ventilated if the state of the mine requires it.

Plan 3 shews the method of ventilating seams having an inclination, and being worked in districts or panels. The middle bord and the upper headways or ends of the main-roads are the intakes or fresh air-roads, and also the travelling-roads of the mine unobstructed with doors. All the districts are supplied with air from these main-intakes or fresh air-roads, by regulators placed on the delivery. In Plan 3, Parts 1 and 2, two panels are ventilated by one current of air; one panel working whole coal, the other pillars. The whole coal workings are first ventilated, the air then passing to the pillar workings in the next panel, and returning down the far bords or drifts. This mode of ventilating the panel has a tendency to draw the gas from the goaf towards the men at the faces of the pillars, and is not to be compared for safety with the panel ventilation shewn in Plan 2, and Plan 3, Part 3.

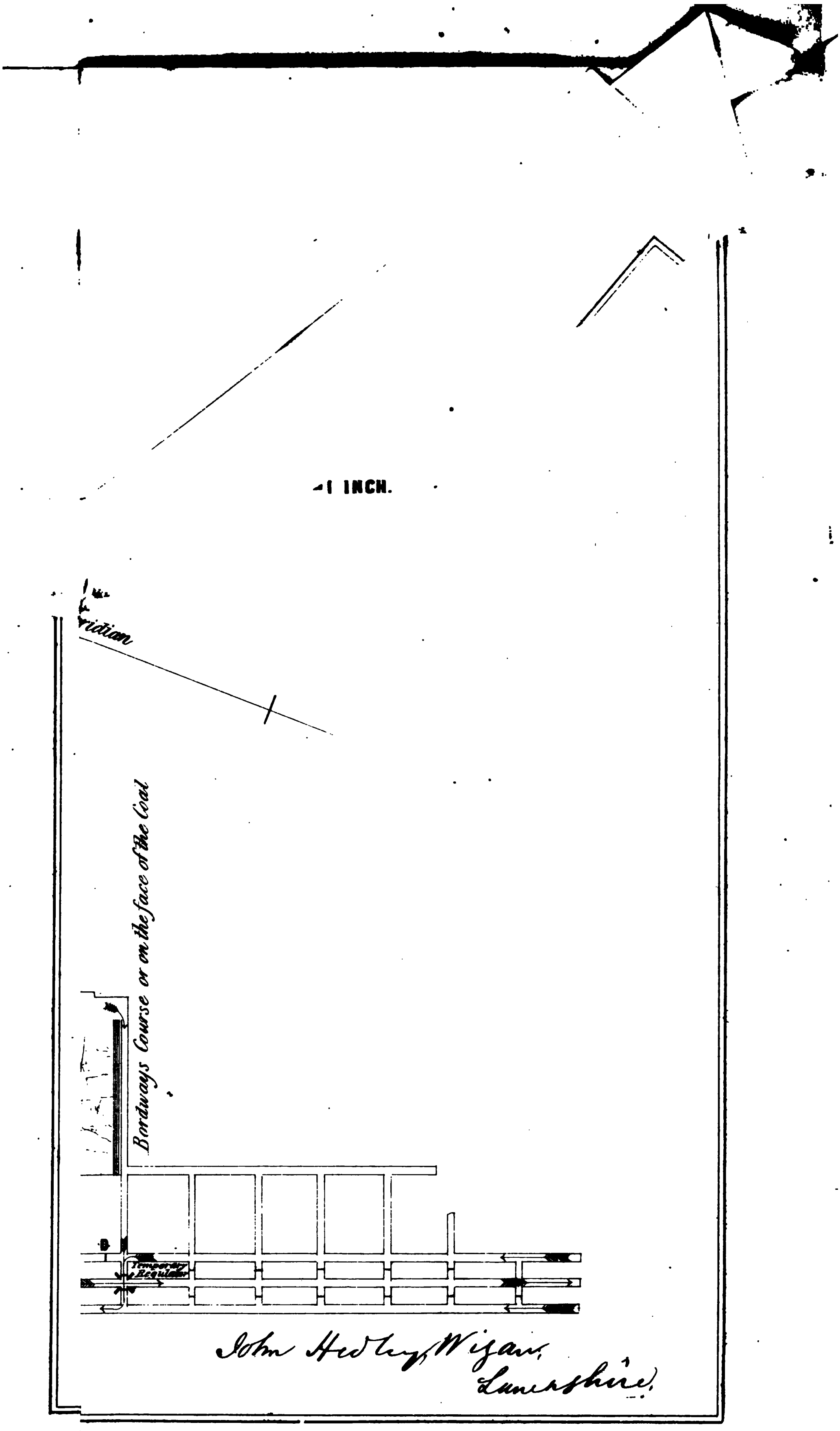
In Plan 3, Part 3, the panels have each a separate

ventilation; the return from each is delivered at the rise part of the panel, where the gas would by natural drainage be given off. Some previous preparation of the workings is here necessary, before a panel can be worked with a separate ventilation. The headways or ends at the low side and top side of the panels must first be driven, and connected with a pair of drifts or bords, separated with the panel or division pillar at the extremity of each panel. The main current of air passes up the near bord or drift of the panel, and sweeps the faces of the bords by means of bratticing. Each of the other bords or drifts is ventilated with a scale of air. In working the pillars, the air sweeps across the face, presses towards the goaf, forces the gas from the men, is sent over a portion of the goaf, and carries any liberated gas into the return.

The goaves are connected with the return air-courses, so that a drainage of gas will go forward. The exploring drifts can each have a separate ventilation.

If packs or stone pillars are built along the panel pillar, as shewn at (A), in Plan 3, a current of air will sweep between it and the goaf, which will be some protection to the men working this pillar.

In Plan 3, Part 4, each panel is shewn with a separate ventilation. The return passes down the far bords, and is carried over the intake by a crossing, into the return or lower headways or end.


1 INCH.
ridian
Bordways Course or on the face of the Coal
B
Temporary Regulator
John Hedley, Wigan,
Lancashire.

CHAPTER VI.

Long Wall or Long Work Workings.

Long Wall, or Long Work, is common to the Derbyshire and other Southern Coal Fields. To get a seam economically by this plan of working, the roof must fall freely in the banks, and in suitable pieces for building stone walls or packs which will bear great pressure upon them, so as to maintain roads through the goaves or excavated parts of the mine for air, and for conveying coal from the bank face.

By this method of working, the coal is got in different Coal Fields in banks of various widths, of from 80 up to 300 or 400 yards, and various lengths of the face are apportioned to each Collier. In some of the Southern Coal Fields each man has a greater length of face allotted to him than he can get down in a day by once holing or undermining. The coal got down one day is removed the next, while the Collier is working at the other part of his apportioned length of face; thus a portion of the bank is idle daily, which would be inconvenient in thin seams raising large quantities, from the great extent of mine required to be opened; in this case therefore each man must only have such a length of face apportioned to him

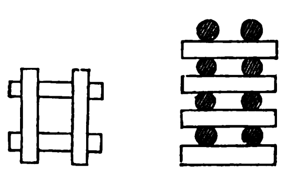
as he can get for a day's work by once holing or undermining. The length of the face for each man, and the number of men working together, will determine what number of roads must be made through the goaf in each bank. According to Plan 4 each man has seven yards of face to work, and four men send their coal down each road, the roads being 28 yards apart. The packs or stone walls, made through the goaf to maintain roads, should be carefully built, so as to be solid and firm, and not liable to be crushed into the roads by the sinking of the roof. This is much neglected by some persons when introducing this mode of working, and frequently the cause of failure, through the packs or pillars being little better than a heap of loose material. The solidity of these supports is very important; unless they are firm, both goaf-roads and bank face will be buried. With a suitable roof, and proper management, there is however no fear of a failure.

When the Colliers have finished their work, the packing men follow, and build or lengthen the main packs the distance the face has advanced during the day, make good and re-set the other supports of the roof, adjust the roads along the bank face, and enlarge the goaf-roads, either by taking up the floor or blowing down the roof, where the sinking of the roof has contracted the size of them. The experienced packing men are expert in building the packs firm enough to bear the weight of the sinking roof. The packs or pillars

are generally built by contract, either by the cubic yard, the lineal yard, or at a sum per score, dozen, or ton of coal sent from the bank. The maintaining of the goaf or pack-roads, and the setting of the timber supports, are generally included in the packing men's duties. The charges for packing, &c., will vary from threepence to sixpence per ton according to circumstances. The increased yield of round coal by this method of working more than compensates for any small extra cost incurred.

When the cost of conveying the coal by manual labour, together with that of maintaining a road up each goaf-road or pack-gate is considerable, these expenses may be reduced by forming a cross-gate or pack-road across the goaf (See Plan) connecting the goaf-roads together, so that the coal can be conveyed along the cross-gate to a main goaf-road, which will be a horse-road or incline; the other goaf-roads, up to the cross-gate, will not require to be maintained, except the two extreme ones for air.

The roof along the face requires strong supports, such as cast iron props, or square wood pillars, formed with pieces of timber two to two feet six inches long (See Figures annexed). These pillars must be set on small coal or loose material, to facilitate their removal when a weight is upon them.



PLAN ELEVATION

The roof in the intermediate space between the main packs is in some cases supported by a series of continuous stone pillars three feet wide, from five to seven yards apart, running parallel with the main-packs. This is not necessary, as it prevents the free falling of the roof, and causes large chambers to be formed in which the fire damp may accumulate, and be liable to be forced out at the face in large bodies, by falls of the roof or changes in the atmosphere. The roof in the intermediate space should be encouraged to fall freely and as compactly as possible, leaving few cavities for gas to accumulate in. Stone pillars two to three feet square, erected immediately behind the timber props or puncheons along the face, will be found most suitable intermediate supports, as they will ease the weight on the coal face and props better than a series of continuous pillars which partly uphold the roof, and cause a greater area of it to be pressing with its weight upon the coal and timber. When practicable, the pillars should be built next to the wooden or iron props with the material that forms the back pillars next the goaf, instead of building other pillars with the fallen roof, and leaving the rest standing, and preventing the free sinking of the roof. These pillars should also be erected on small coal or loose material, in order to facilitate their removal should a weight come upon them.

In working seams which have a cubical fracture, by long work, on the face of the coal, or across the cleat or

cleavage, the coal will get in long pieces, as the weight on the face of wide banks separates the coal along the cleavage: thus the coal neither looks so well, nor yet takes the market so well in some instances as cubical coal, nor will it bear turning over without greater loss by breakage. Such seams should be worked on the end of the coal, or in the direction of the cleat or cleavage, and the coal will get in cubical blocks; it may also be worked by the Collier breaking into the face of the bank (when it is opened at right angles to the cleat or cleavage) five to seven yards, and getting this width out parallel with the face for the length apportioned to him, which is the same mode of working as shewn in Plans 14, 15 and 16, except that, in the former case, the coal is worked from the shaft, in the latter, towards it.

The long wall method of working a mine very materially assists in the getting of coal, as the weight on the face of the banks separates the coal from the bed without the use of powder, and frequently without the use of wedges after the undermining is finished. Where the coal leaves the roof freely, it is necessary during the process of holing or undermining to support it with short props placed beneath the undermined part of the bank face; or, in the place of props, a portion of coal is left (technically called a Tack), so as to prevent the coal from falling before the undermining is completed.

The great simplicity of working by long work and the ease with which it is ventilated, as compared with other methods of working, is a strong recommendation for its adoption, where circumstances are favorable. When more attention shall be drawn to this mode of working, I have no doubt of its general application to seams favorable for it.

CHAPTER VII.

VENTILATION OF LONG WORK.

SEAMS got by Long Work are generally ventilated by the whole body of air circulating through the mine in a single current—a system of ventilation which has no supporters among the intelligent Viewers of the present day.

I have shewn the method of ventilating by splitting the air in Plan 4. Each bank has a separate current of fresh air which sweeps across the face, and returns to the up-cast shaft without passing along any travelling-roads of the mine, except a short length of goaf-road. The middle main-road on Plan 4 is the main-intake or fresh air-course, and is also a travelling-road. Each bank takes its supply of air from this main-intake, the supply being controlled by a regulator (R) on the Plan, fixed near where the air is delivered from the bank into the main-return, or at the most convenient point. Air-doors on the main-roads of the mine are dispensed with.

The two banks on the south side of the Plan working simultaneously, illustrate the mode of ventilating the banks by splitting the air. Three goaf or pack-roads convey the air to the banks, the supply of which is

apportioned to each bank by means of the regulators. The stoppings (S) at the bottom end of the banks pass air to ventilate the other goaf-roads. The two goaf-roads at the extreme of the banks are return air-roads, and must be maintained of a sufficient capacity for that purpose. Double air-cloths should be hung in the cross-gates in order to send the air forward to the bank-face, the constant sinking of the roof and heaving of the floor in the cross-gates preventing the use of doors. The return air from the south bank is conveyed over the intake at (A), by a crossing into a main-return, and the same crossing serves to convey the air from the next south bank. These arrangements are suited to a seam which is level along the coal face. If the seam has an inclination along the face of the coal, the main-roads from the bank will be on the low side, and should also, if practicable, be the fresh air-roads, in which case the delivery of air from the bank will be on the high side.

All the exhausted banks should be connected on the rise with the return air-courses, to facilitate the drainage of the gas; and if the goaf or pack-roads are open, air should be sent through them to carry the gas away.

In flat seams the gas will be more liable to accumulate in the goaf behind the workmen, than in seams which have an inclination; in these latter seams the gas will escape by natural drainage from the goaf, and be carried away by the current of air which sweeps along the bank face. If danger is apprehended from

the gas in the goaf, the safety lamp should be used under proper regulations.

The Ventilation of long work does not require the use of bratticing to convey the air to the working face as in bord and pillar workings. In long work the whole of the air in each current sweeps along the bank face, which is of great advantage to the men, particularly in deep seams, where the warmth of the mine renders it inconvenient for them to work out of the main air-way.

WIDE WORK

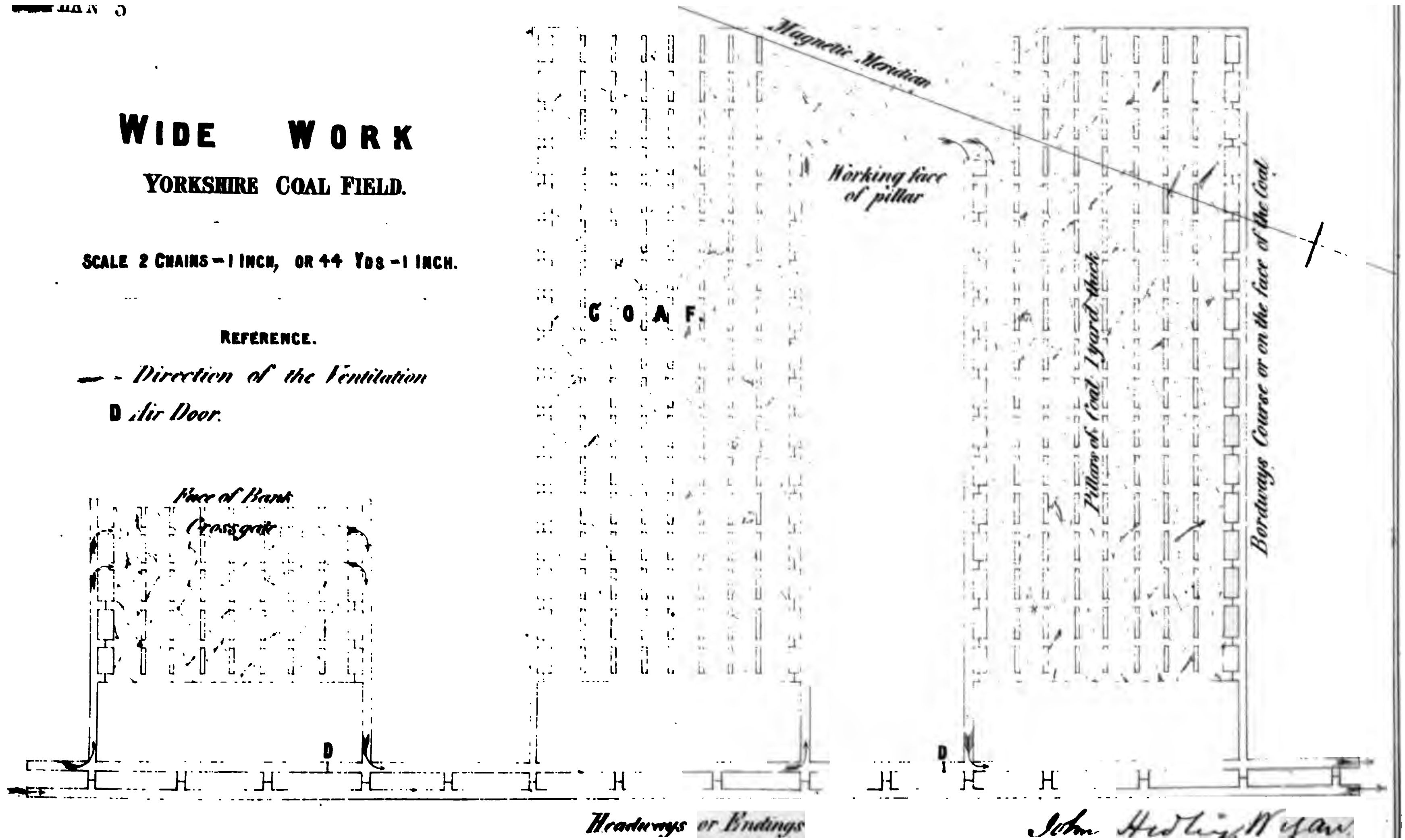
YORKSHIRE COAL FIELD.

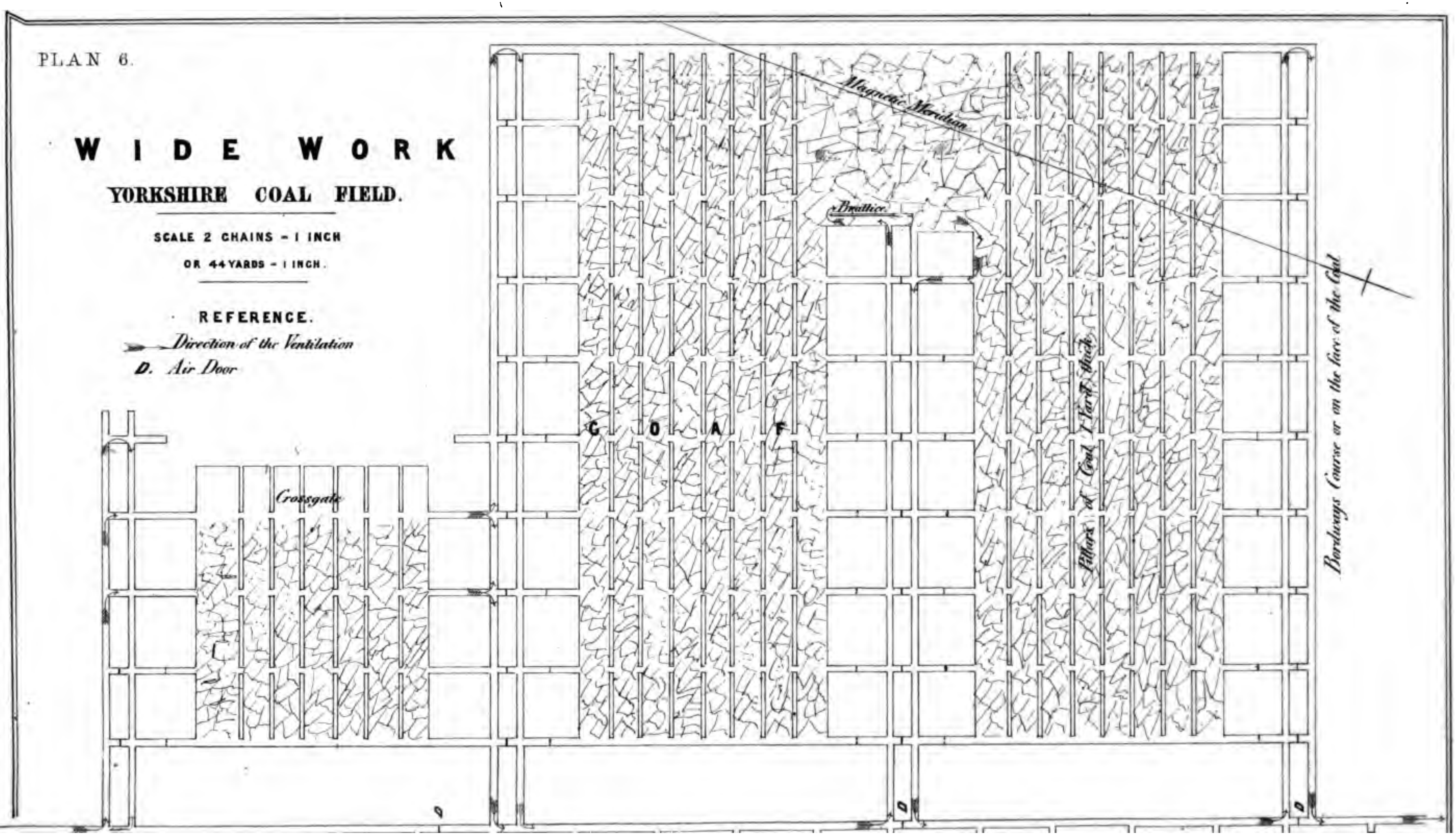
SCALE 2 CHAINS = 1 INCH, OR 44 YDS = 1 INCH.

REFERENCE.

— - *Direction of the Ventilation*

D *Air Door.*




PLAN 6.
WIDE WORK
YORKSHIRE COAL FIELD.
SCALE 2 CHAINS - 1 INCH
OR 44 YARDS - 1 INCH.
REFERENCE.
Direction of the Ventilation
D. Air Door
Crossgate
G O A F
Brattice
Magnetic Meridian
Pillars of Coal 1 Yard thick
Bordways Course or on the face of the Coal
D
D
D

PLAN 7.

WIDE WORK.

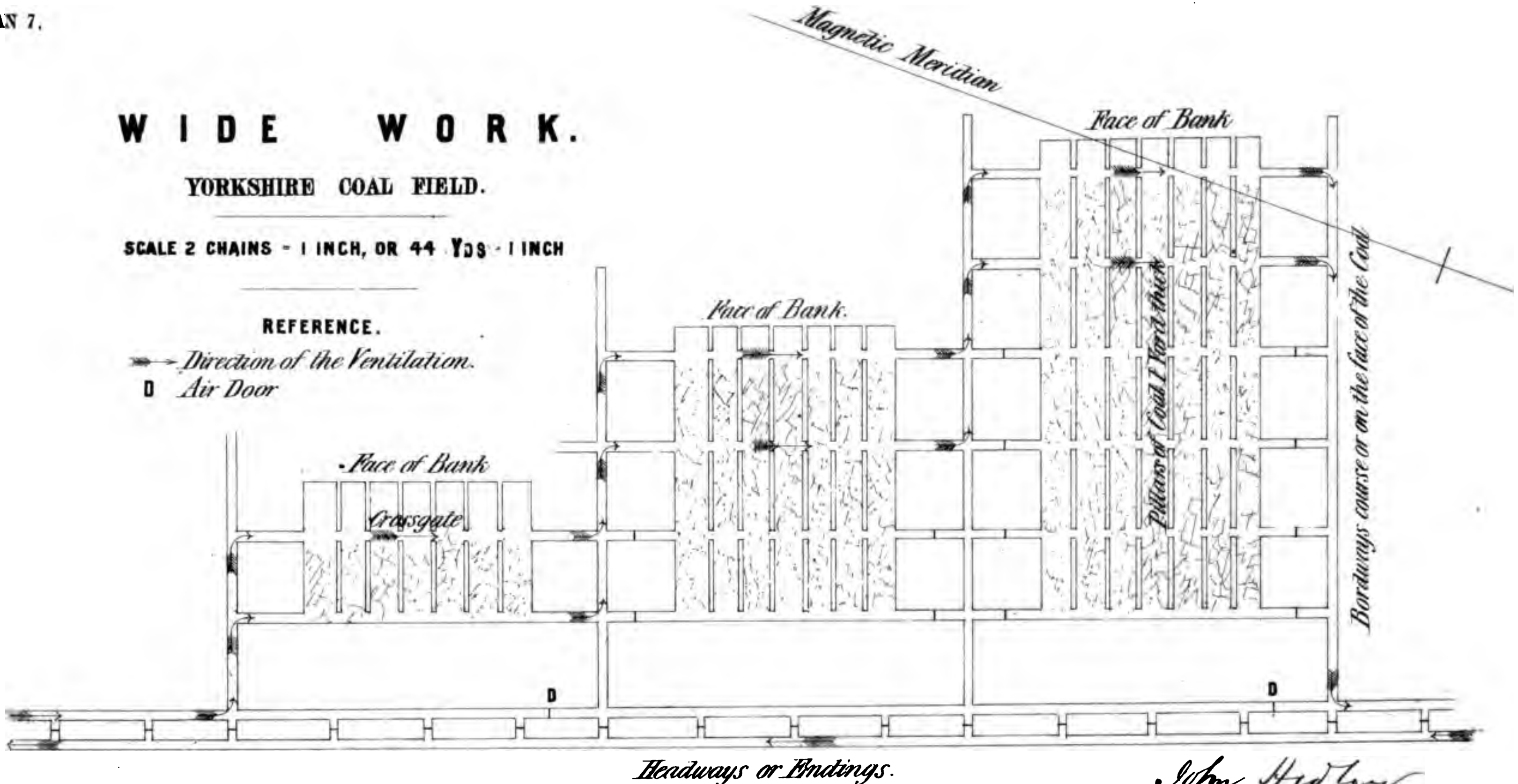
YORKSHIRE COAL FIELD.

SCALE 2 CHAINS - 1 INCH, OR 44 YDS - 1 INCH

REFERENCE.

→ *Direction of the Ventilation.*

D *Air Door*



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Lancashire

Maclure, Macdonald & Macgregor.

CHAPTER VIII.

Wide Work, Yorkshire Coal Field.

Plans 5, 6 and 7, illustrate the Wide Work method of getting coal. This method is only applicable to seams with a strong roof. The serious loss of coal which falls upon the Lessee or Colliery Owner when the coal rent is paid by the acre, as is the case in some Coal Fields, forms one great objection to it.

According to this plan of working, the coal is got in banks of different widths varying from 50 to 100 yards and upwards, a bank consisting of a series of bords from 6 to 10 yards wide, and each bord being separated by a pillar of coal one yard thick, which is left in the mine. A communication is made across the bank at various distances of from 10 to 20 yards, according to the fiery state of the seam. Along this communication or cross-gate the road is laid with sidings or branches to the bank face, in order to convey the coal away, and it is frequently necessary to support the roof from this road to the bank face on timber, until the bank is worked up a sufficient distance for a new cross-gate.

A pillar from 20 to 40 yards wide is left between these banks, and got out when the banks are finished.

These pillars are generally much crushed by the weight upon them, caused by working the banks on each side, and the yield of round coal from them is low.

Plan 5 shews one modification of the mode of working. A narrow bord is driven up each side of the bank, leaving a pillar from three to four yards wide up to the goaf or old works. In some seams this pillar when worked yields very small coal.

Plan 6 shews another position of the bords in the pillars between the banks. Here a stronger pillar is left between the bords and the goaf or old works. As in the other case, this pillar becomes crushed by the weight upon it.

In Plan 7 only one bord is driven up the pillar, and a communication is made at intervals with the banks on each side. The pillar in this case becomes also crushed, and yields much below the average of round coal.

This mode of working is in some respects similar to the bord and narrow pillar of the North, which may now be considered as almost discarded, except under peculiar circumstances in shallow seams. In Yorkshire this method of working is practised in seams of from 400 to 500 feet deep, but it is becoming to a great extent superseded in many Collieries by its combination with long work.

CHAPTER IX.

Ventilation of Wide Work.

The general system of Ventilation practised in Yorkshire is applied in the ventilation of wide work by carrying the air round the mine in a single current.

The air is passed up the pillar-bord on one side of the bank, along the cross-gate and down the pillar-bord on the other side of the bank, and so circulated through each working bank.

In working the pillars, the air is taken up one of the pillar-bords, across the face and down the other bord. The direction of the Arrows on Plans 5, 6 and 7, will shew the circulation of air to the banks and pillars.

In this system of ventilating, the return air from the banks and pillars has to pass along the travelling-roads of the mine, bringing the foul air from the goaves into contact with the men.

This plan of working a fiery seam is objectionable. The coal pillars left in the banks keep up a considerable area of roof, thus forming large chambers for the accumulation of gas, which is liable to be forced out by the falling roof.

In my remarks on Yorkshire Long Work in another chapter, I shall enter more fully into the system of

ventilation generally adopted, and illustrate an improvement in Ventilation by splitting the air.

NG WORK

ORKSHIRE COAL FIELD.

nciple of Ventilation generally adopted

SCALE 3 CHAINS = 1 INCH.

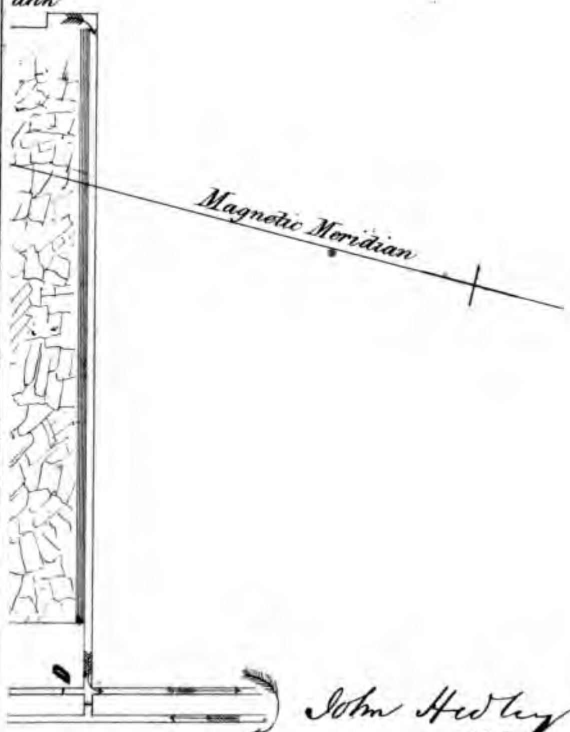
REFERENCE.

n Packs to maintain a road through the Goaf

ection of the Ventilation

Doors

'ank



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Lancashire

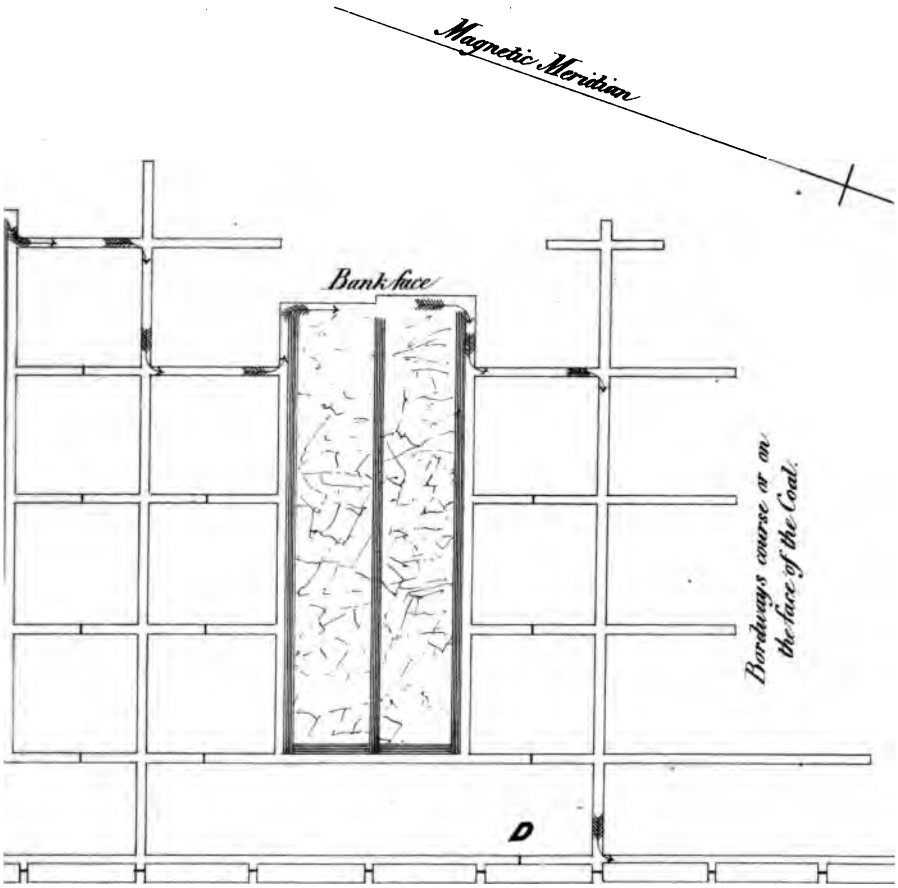
NG WORK,

KSHIRE COAL FIELD;

e of Ventilation by splitting the Air.

SCALE 3 CHAINS–1 INCH.

Lanarkshire



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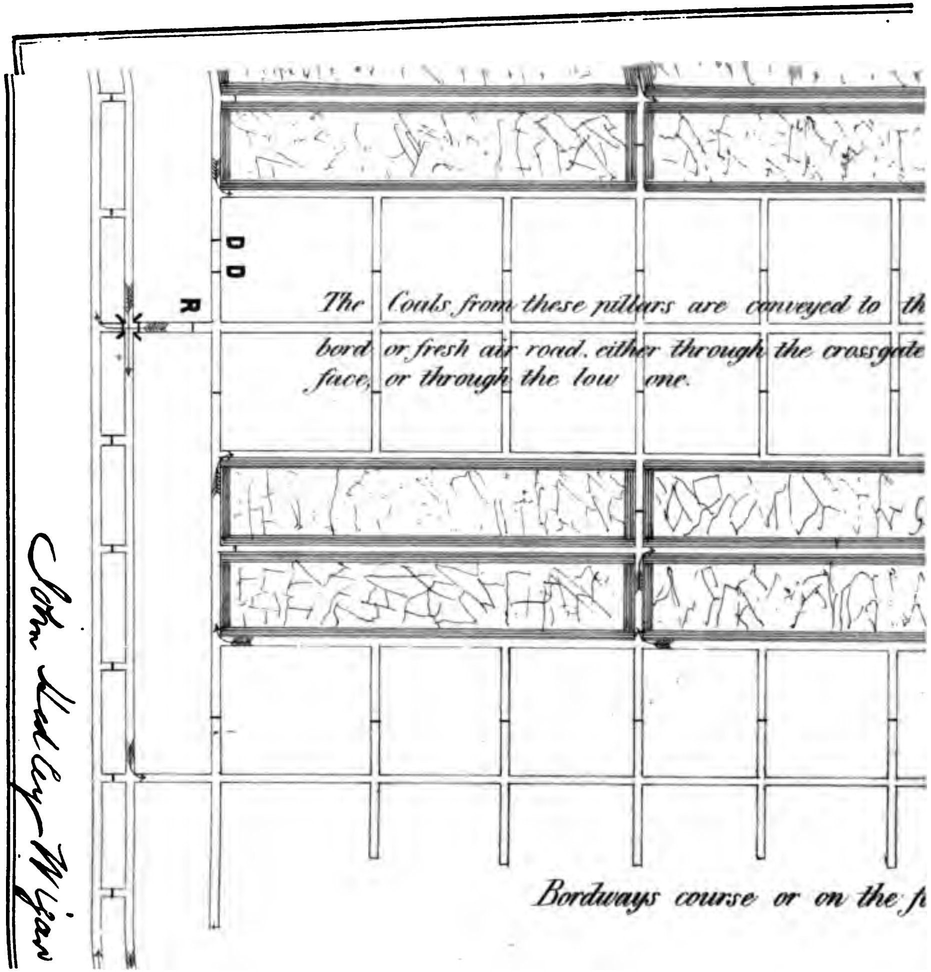

D D
R
The Coals from these pillars are conveyed to th
bord or fresh air road, either through the crossgate
face, or through the low one.
Bordways course or on the f
John Hedley Wigan

CHAPTER X.

LONG WORK, YORKSHIRE COAL FIELD.

PLANS 8 and 9, 10 and 11, illustrate the system of working by Long Work, as practised in the Yorkshire Coal Field, and which is a modification of the wide work plan of working peculiar to this Coal Field. Banks are worked of various widths, leaving pillars between 20 yards and upwards thick: goaf-roads are formed up each bank to convey the coal from the face, and also to supply it with air. The number of roads for each bank will depend on the length of face apportioned to each man, and the number of men working together. The mode of working shewn on Plans 8 and 9, leaves the pillars solid between the banks, the pillars being got out after the banks on each side are finished. The coal is brought from the pillar face down roads on each side, formed to convey coal from the banks.

The intermediate supports between the main packs, and the timber supports along the face of the banks, will be the same as described in a former chapter on Long Work.

The small pillars of coal left between the banks are generally much crushed by the pressure; to avoid this

some Viewers leave stronger pillars, as shewn in Plans 10 and 11. The coal however will still suffer from the pressure, and coal surrounded by tracks of goaf or old workings becomes more or less crushed.

Plan 10 shews the arrangements generally adopted in working and leaving wider pillars between the banks. A bord is driven up the middle of the pillar when the banks are worked, communicating according to circumstances at different distances with the banks on each side. Strong walls or packs are built along the pillar side as the banks are worked, to form roads for air, and for the purpose of conveying coal from the face to the first opening that communicates with the pillar-bord, down which bord the coal is conveyed from the adjoining side of the bank. Two goaf-roads are here used, each of the men having a considerable length of face to work.

Plan 11 illustrates the same method of working, with a different arrangement of the travelling-roads from the banks. The whole of the face is here at work, and to each man is apportioned such a length as he can get down in a day by once baring or undermining. Three goaf-roads are formed, one up the middle of the bank, the other two, as in Plans 8 and 9, along the pillar side. Cross-gates are formed across the bank at intervals, and the goaf or pack-roads are not kept good below the cross-gate last formed for travelling, but they are maintained of a sufficient capacity to ventilate the pillar between the banks when it is got.

The coal is conveyed from the banks on each side of the pillar, along the cross-gates to that pillar-bord which is the intake or fresh air-road for the banks on each side. The coal from the pillar, down which the return air passes, is conveyed through the doors (DD) at the bottom end to the fresh air-bord. If the cross-gates in the banks are maintained, the coal can be conveyed along the cross-gate nearest the pillar face to the fresh air-bord, and the doors at the bottom end of the pillars will not be required; but either doors or double cloths must be hung in the pillar openings opposite the cross-gate in use.

Where the measures above the coal are strong, the roof does not fall freely in these narrow banks, and thus large cavities are formed in the goaf in which gas may accumulate; more pressure is also brought upon the pillars between the banks than when the roof falls freely and closes up the goaf. With a roof strong, yet suitable for long work, the banks may with advantage be driven wider than is shewn on Plans 8 and 9, 10 and 11.

CHAPTER XI.

Ventilation of Long Work, Yorkshire Coal Field.

Plans 8 and 10 shew the system of ventilation generally adopted in this Coal Field: one current of air being circulated through the mine. By this method it is impossible to ventilate a fiery mine without great risk. The circulation of the air to different parts of the mine, in many cases, depends upon doors placed in the travelling-roads; and whatever gas is liberated from the seam or goaves is carried by the air through the workings and travelling-roads.

Plans 9 and 11 shew the mode of ventilation by splitting the air.

Plan 9 shews the method of ventilating the same system of working, laid down in Plan 8, by splitting the air, without any material alterations in the arrangement of the workings. By this latter mode, one of the main upbrows or bords is the main intake or fresh air-road, and the higher headways or ends convey the fresh air for the purpose of ventilating the banks on each side of the main bords. Crossings are formed at places shewn on the Plan, to convey the return air from the banks over the fresh air-courses. The mode in which

the air is distributed to the banks is shown in the workings on the south-east side of the Plan. Following the first headways or end from the main-intake or fresh air-bord to the point marked (S), a split of the air is made, which is again divided in order to ventilate two banks and two pillars to the right, and two banks and two pillars to the left. The return air from the banks and pillars on the left hand side is delivered into the lower headways or end at the crossing marked (C) on the Plan, the lower headways or end being used solely for return air. The goaves are also drained on the rise into these return air-roads.

Plan 11 shews the ventilation of the mode of working laid down on Plan 10, by splitting the air. Three main upbrows or bords are here used, the middle one being the main intake or fresh air-road, the side bords return air-roads. The higher of the headways or ends are intakes or fresh air-roads branching out of the upbrows or bords, to supply the banks with air.

The method of ventilating the banks and pillars is shewn in the workings laid down on the south-east side of Plan 11. Following the first headways or end southward from the upbrows or bords to the point marked (S), a split in the air is made, which is again divided in order to ventilate the banks on each side of the pillar bord. When these banks are worked up, the same arrangement ventilates the pillars between the banks, the goaf-roads along the pillars being maintained for

that purpose. The workings shewn on the west side of the Plan illustrate the method of ventilating the banks which are worked simultaneously. Regulators (R) supply air to each bank and pillar.

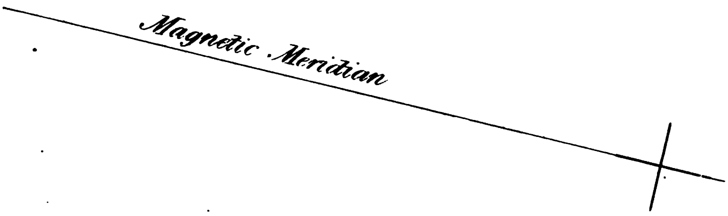
The air from the right hand bank is delivered direct into the return. From the bank on the left hand it is carried over the intake or fresh air-course by a crossing at (C) into the return, and this crossing delivers air from the next south bank and pillar. The return air-courses are not used as travelling-roads, the travelling-roads in the mine being the intakes or fresh air-roads.

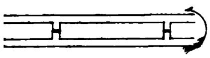
The workings of Plans 8 and 9 cannot be as effectually ventilated as those of Plans 10 and 11. In Plans 8 and 9 air which has ventilated the banks will circulate to a greater extent along the travelling-roads in the mine.

In seams with an inclination there is, in either arrangement, much more danger to be apprehended from the gas in getting the pillars, than in working the banks. During the working of the banks to the rise, the gas drains from between the packs to the face, and is carried away by the ventilation. During the working of the pillars, surrounded with goaf or old works, an accumulation of gas takes place in the goaf, although the highest part of it may be connected with the return to drain it; the closing of the goaf will limit the extent of drainage, and thus cause the gas to accumulate in it. Atmospheric changes will liberate some of this accu-

mulated gas, which will be carried along with into the other parts of the mine ventilated by tl current.

This modified system of long work cannot effectually ventilated as long work in the sol shewn in Plan 4, neither will the yield of large so great.





NARROW BORDS AND LONG WORK.

The principle of Ventilation generally adopted in the

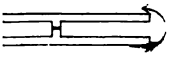
YORKSHIRE COAL FIELD.

SCALE 3 CHAINS OR 66 YARDS=1 INCH.

REFERENCE.

→ *Direction of the Ventilation.*

D *Air Door*



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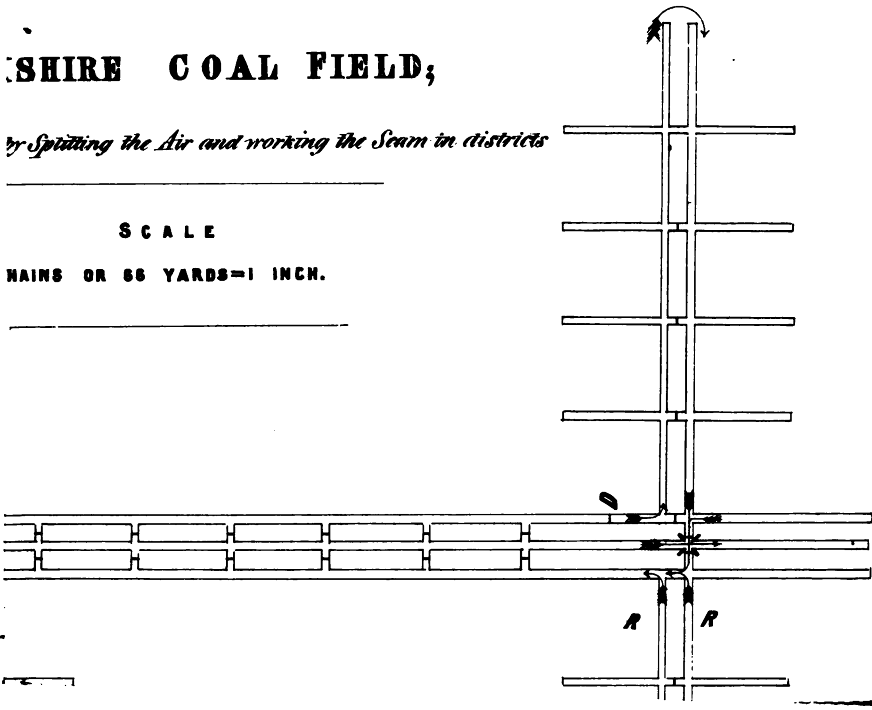
RDS AND LONG WORK.

:SHIRE COAL FIELD;

by Splitting the Air and working the Seam in districts

SCALE

HAINS OR 66 YARDS=1 INCH.



CHAPTER XII.

Narrow Bords and Long Work.

Plans 12 and 13 illustrate the mode of working by narrow bords and long work, a system practised in the Yorkshire and some of the Southern Coal Fields, and adapted for working a seam with a tender roof.

By this plan of working, a pair of narrow bords, about six feet wide, is driven, separated with a pillar of coal one to four yards thick; and a pillar from twenty to thirty yards is left between each pair of bords. When the bords are driven up a determined distance, the pillars are cut across, and a long face of coal opened and worked towards the shaft or homewards, leaving the goaf behind, which does not require to be supported with packs or walls, as in working long work from the shaft or from home.

Plan 12 shews the arrangement generally adopted in working. Two men work on each side of a pair of bords.

Plan 13 shows an arrangement of the workings for getting the seam in districts or divisions. A pair of bords is driven at the extremity of a district, and kept good by strong pillars up to the goaf; these pillars are not got out until the districts are worked on each side,

and the division bords no longer required. Reference to Plan 13 shews the use of these division bords in the ventilation of the workings. The pillars which support these bords are left some time surrounded with the goaf, and suffer from pressure: it is necessary to leave them so for a time, so as to apply the best system of ventilation to this method of working. Packs or stone walls built along these pillar sides will preserve an air-road between them and the goaf.

Considerable preparation and outlay, as will be seen from the Plans, is required in this method of working before much coal can be raised: the bords must first be driven to a considerable extent before the mine can be vigorously worked.

The remarks made in a previous chapter on long work, in regard to the working of coals with a cubical fracture, apply to working by long work, as now described.

Some roofs are of such a tender nature as to fall much in the narrow bords. If there is height in the seam, a few inches of coal left at the top will make a good roof where the coal is strong.

CHAPTER XIII.

Ventilation of Narrow Bords and Long Work.

Plan 12 shews the method of ventilation generally adopted by circulating one body of air through the mine. The risk, danger, and inefficiency of this method, I have already alluded to.

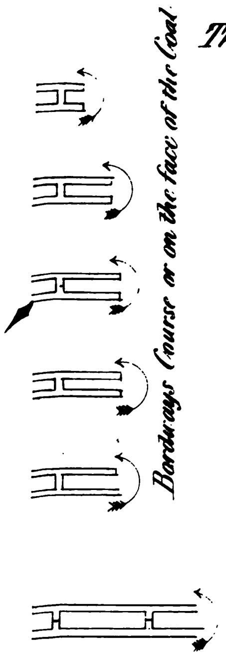
Plan 13 shews the method of ventilation by splitting the air. Three main-roads traverse the seam; the middle road is the intake or fresh air-road, and also the main travelling-road. The seam is worked in districts or divisions; each district is fitted with a regulator (R) for the supply of air. The method of ventilating the districts is shewn on the south-east side of the Plan. The two middle pairs of bords in the district convey the air to the face of the banks. The doors (DD) at the bottom end of the bords in the headways or end, have a scale of air to ventilate the other bords connected with the banks. The air sweeps across the face of the bank, and is forced over a part of the goaf in its course to the return, and drives the gas contained in the goaf from the men, taking it to the upcast shaft without passing along any of the travelling-roads of the mine.

Packs or walls built along the division-pillar sides will preserve an air-road between the pillar and the goaf

for the protection of the men when working the pillar, and will also facilitate the drainage of gas from the goaf.

If division bords are not used, the air will sweep across the bank face and down the far pair of bords in the bank, and instead of pressing towards the goaf and keeping back, and carrying away, the gas from the face, its tendency is to draw the gas or foulness from the goaf towards the face and into the roads used by the workmen.

The air-courses in narrow bords require great attention to keep them of a sufficient capacity for ventilation purposes; the falling of the roof may so contract the area, and reduce the ventilation, as to endanger the safety of the mine. I have repeatedly witnessed this in mines ventilated by the air passing through in one current.



NARROW WORK.

On the End of the Coal or Headways Course.

The principle of Ventilation generally adopted in the

YORKSHIRE COAL FIELD.

SCALE 3 CHAINS OR 66 YARDS=1 INCH.

REFERENCE.

→ *Direction of the Ventilation.*

D *Air Door*

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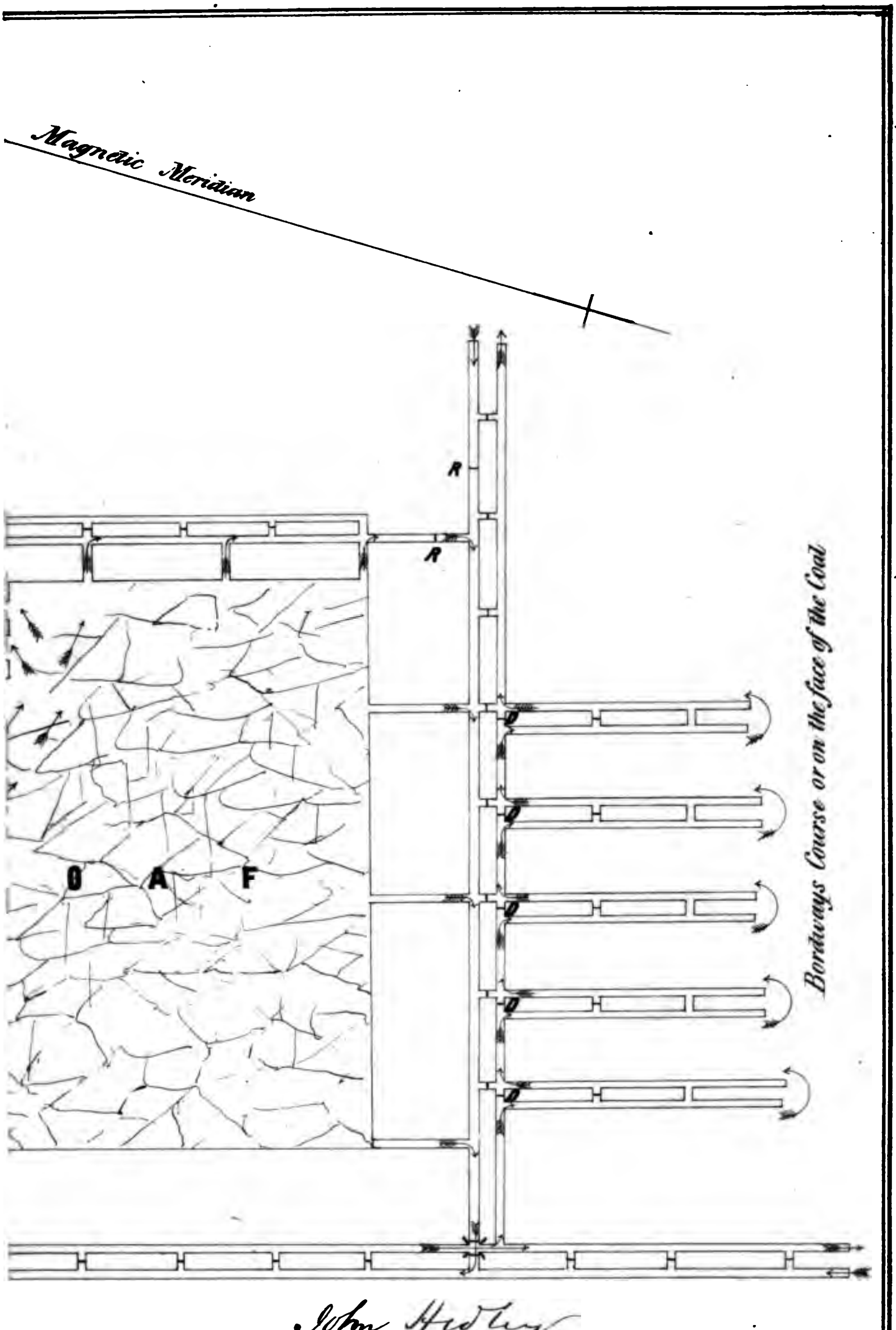

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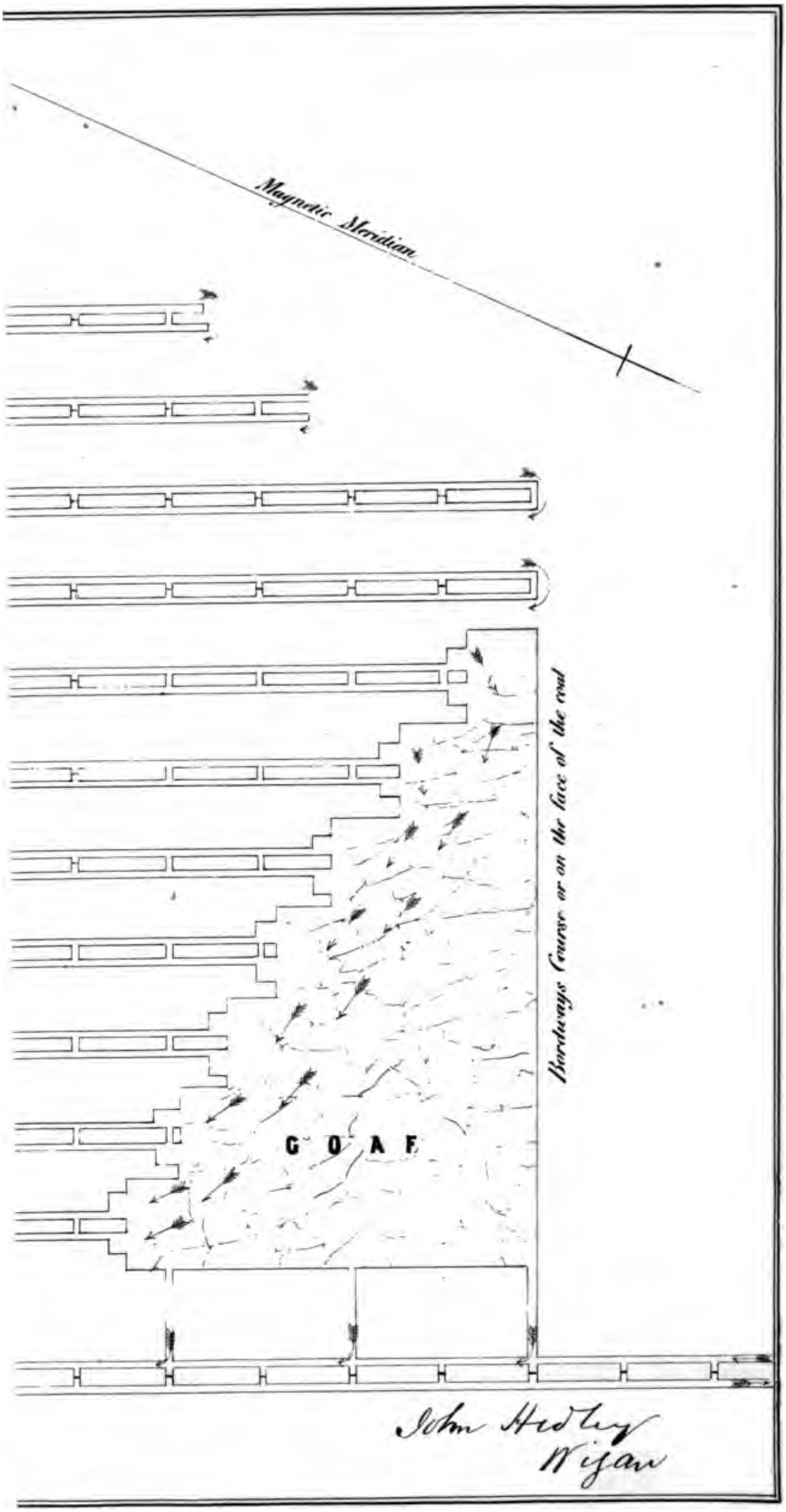


Magnetic Meridian
Bordways Course or on the face of the coal
GOAF
John Hedley
Wigan

CHAPTER XIV.

Narrow Ends or Headways Workings.

Plans 14, 15, and 16, illustrate the method of working a seam with a tender roof, by driving narrow ends or headways, about six feet wide, in pairs, separated with a pillar of coal one to four yards wide, and a pillar of thirty yards wide left between each pair of ends or headways. These ends are driven up a determined distance, each pair bringing back one-half the pillar on each side by working the coal in jenkings, ribs, or faces, six to eight yards wide, at right angles to the ends or headways.

By this mode the men work with the goaf to their side, and the roof is supported from the headways or end in each jenking or rib until it is worked to the middle of the pillar, when the props are removed and another jenking or rib six to eight yards wide is entered from the side of the end or headways. The coal is worked on the face, and the weight from the roof is on the end of the coal, which will bear greater pressure than on the face without affecting its cohesion. The coal gets in cubical blocks by working this way, although it may be inclined to get in long coal by working in a long face, with the pressure of the roof on the face of the coal.

The pillars in division 1, on Plan 15, must be worked

out before the pillars in division 2, in the same district, are begun; and the same arrangement must be carried out in working other divisions in the mine, in order to preserve a separate ventilation to each division.

CHAPTER XV.

Ventilation of Narrow Ends or Headways Workings.

Plan 14 shews the method of ventilation generally adopted by circulating one body of air through the mine. The same evils attend this method of ventilation in this system of working as in others already described. Reference to the Plan will shew the arrangements for conducting the air through the mine.

Plan 15 shows the method of ventilation (the arrangement of the workings being the same as in Plan 14) by splitting the air. One of the main-roads is made an intake or fresh air-road, the other a return air-road. Each division of the mine receives a separate supply of air, and the foulness of each division is carried from the mine without passing along the travelling-roads. Reference to the Plan will shew the principle of ventilation. In divisions 1 and 2 the air is sent along two pairs of ends or headways to ventilate between the goaf and working places; one portion of air is forced over the rise part of the goaf into the return air-course, carrying along with it the gas from a part of the goaf adjoining the face; another portion of air is brought down the far pair of ends connected with the goaf,

to ventilate the ends or headways working in the solid. The method of ventilating the south district, on Plan 15, will more effectually separate the goaf ventilation from that of the whole coal workings. The air-doors are removed from the main-road; the two first pairs of ends to the goaf are open to the intake or fresh air; the other ends or headways connected with the goaf are closed, the one by a door, the other by a stopping. The main body of air is taken up the first two pairs of ends to ventilate the working places, and is forced over part of the goaf at its rise extremity into the return. A regulator (R) supplies air to each division of the mine. Another portion of air passes along the main-road to ventilate the ends or headways working in the solid, and is delivered into a return air-course, the supply being governed by a regulator fixed in the return.

Plan 16 shews the arrangement of the workings for a flat seam. The middle main-road is the intake or fresh air-road, from which the ends or headways on each side take their supply of air; part of the air circulates through the ends working in the solid, and returns to ventilate the faces of the pillars. A scale of air opposite the far ends or headways in the working pillars joins the return from the whole coal workings, and this joint current ventilates the working places adjoining the goaf, and passes down the two near pairs of ends into the return. This arrangement of the workings, and method of ventilation, is not adapted to a

fiery mine, as the returns from the workings adjoining the goaf are passed along roads used by workmen. The mode of ventilation shewn in the south district, in Plan 15, is best adapted for a fiery mine.

This system of working a seam does not admit of so efficient a ventilation to the working places adjoining the goaf, as the system of working by narrow bords and long work, shew on Plan 13. The system of working shewn on Plans 14, 15, and 16, leaves an irregular face joining the goaf, which will be seen on reference to the Plans.

CHAPTER XVI.

Remarks on Safety Lamps.

Much has been said of late years respecting the insecurity of the Davy Lamp, in regard to the liability of the flame to pass through the gauze when the lamp is exposed to a current of explosive atmosphere.

Its highly talented inventor, Sir Humphry Davy, demonstrated this, at one of the Earl of Durham's Collieries, shortly after the invention of the lamp, but under circumstances to which the lamp would not be exposed, when in use in the mine.

A strong blower of gas, conducted through pipes contracted at the end so as to discharge the gas with great force, was directed toward a lamp, when the gas fired within the lamp, and after a short time the jet forced flame through the gauze. Sir Humphry had previously cautioned persons against exposing the lamp for a length of time, under any circumstances, to explosive gas, alleging, that when the gauze became heated, flame would more easily pass through it. In order to screen the light from currents of air, he recommended for each lamp the use of a shield, which might serve as a reflector, and also improve the light. This shield is

generally made to encircle two-thirds of the gauze, and to extend nearly to the height of the inner gauze.

If the gas fires at the lamp when it is suspended for use, it should not be rashly removed from its place, as the hasty removal may cause the flame to be carried through the gauze. I have had repeatedly to caution pit men about this.

Sir Humphry Davy also cautioned persons against using a lamp with holes in it of a greater size than the mesh of the gauze, as such a lamp will pass flame when the gas explodes within it. He tested a lamp having a hole one-eighteenth of an inch in diameter bored through the ring at the bottom end of the gauze, the gauze being made with 28 wires to the inch, or 784 apertures to the square inch. When the gas exploded within the gauze, the flame was forced through the hole.

The inner gauze of the Davy Lamp should be six inches high, and from one and four-tenths to one and five-tenths of an inch in diameter, and be formed with 28 wires to the inch, or 784 apertures to the square inch. Malleable or cast iron oil vessels preserve the oil in a better state than brass vessels.

Stephenson's Safety Lamp, as now made, has a gauze two and a quarter inches in diameter, with a glass cylinder inside, and takes its supply of air from the bottom end of the gauze. The glass cylinder protects the flame from currents, but the glass is liable to be broken in the hands of workmen, in which case the fractured glass

may cut the wire gauze, and render the lamp unsafe. If deprived of the cylinder, it would become a Davy Lamp in principle, but dangerous to use in an explosive atmosphere on account of the large size of the gauze; as, in proportion to the capacity of the lamp, would be the heat of the gauze, or the material that encloses the flame.

Clanny's Lamp is made with a strong glass cylinder around the light, with a gauze from three to four inches high, fitted into the plate that secures the top of the cylinder. The light is also in some cases surrounded with a cylinder, one-half of which is metal plate, the other half strong glass. Glass to protect the light is objectionable on account of its liability to fracture; and in the case of the Clanny Lamp, its fracture would expose the flame. A fall of coal, a fall from the roof, or the lamp being forcibly brought into contact with an unyielding substance, might destroy its safety; whereas that of the Davy would, under such circumstances, probably remain unimpaired. I have examined several Davy Lamps which have been crushed by falls of coal and roof, without having their safety diminished, and although the gauzes have been much crushed, they have not been torn. The Clanny Lamp affords four times as much light as the Davy Lamp.

Different modifications of the Davy Lamp are used in this country and on the continent. Among these may be mentioned Upton and Roberts's Lamp, which gives a

more feeble light than the Davy; and the Lemielle Lamp, used on the continent, which is similar in construction to the Stephenson Lamp, but with a gauze of the same capacity as the Davy. Preference is generally given to the Davy Lamp, which I have always found effective and secure.

No lamp should be used with an outside oil tube. If the stopper is removed, and the gas fires at the lamp, the flame will probably be forced through the tube.

All lamps should be examined carefully every day, as many explosions have without doubt occurred by using faulty lamps. I have met with many lamps in use in an unsafe state where it was the practice for the pit men to clean and trim them.

Benjamin Biram, Esq., Viewer, Wentworth, Yorkshire, has invented a Safety Lamp for use in Mines. The greater portion of this lamp is made of thin metal plate, with a wire gauze three and a half inches long by two and a quarter inches wide, fixed in front of the light; a gauze cylinder, two inches long, and one and a quarter inches in diameter, is fitted to the top of the lamp chimney, and a reflector to improve the light is fixed inside the lamp. The large size of the body of this lamp (being more than double that of the Davy) is objectionable; and if the lamp is exposed to an explosive gas, I find that the metal, and gauze fitted in the front of the lamp, sooner becomes heated than the wire gauze of the Davy lamp. Sir Humphry Davy remarks, that if gas is

exploded in a confined vessel having few apertures, or within a wire gauze with apertures of a greater size than the mesh of the gauze, the flame will communicate sooner with the atmosphere outside than if the whole surface of the lamp offered an uniform resistance. These remarks appear to me applicable to such a lamp as Mr. Biram's, as the resistance to the escape of flame is unequal, it being constructed with a surface of thirty-two square inches of metal plate, and only fifteen square inches of wire gauze. Metal plate vessels, either perforated with numerous small apertures, or with an unperforated surface, are much sooner heated than wire gauze, and more liable to pass flame through defective parts.

Few pit men understand the principle of the Davy, or any other Safety Lamp; hence the absolute necessity for some competent person to inspect, clean, and trim them, who will easily detect any defects. Professor Phillips, in his Report on the Ventilation of Mines, remarks that "it seems desirable that pit men should be instructed in the circumstances which have an influence on their own safety," an opinion with which every Viewer will coincide; part of the knowledge obtained from such instructions would undoubtedly be that of the principles upon which Safety Lamps are constructed.

I would advise Managers to be cautious in using lamps which are called "improvements on the Davy Lamp," and to read carefully Sir Humphry Davy's Remarks on

Safety Lamps. These Remarks I have some intention of publishing in a cheap form, and of accompanying them with observations on the qualities, defects, and proper use of Safety Lamps, that pit men may obtain a practical acquaintance with the subject.

The subjoined Rules, for the use of the Safety Lamp, were framed and introduced by Edward Potter, Esq., of the South Hetton, and other collieries, in the North of England:—

Orders respecting the Davy Lamps in use at South Hetton Colliery.

1. No workman is allowed to use a Davy Lamp in the Pillar Working or Broken, without its having been previously examined by the Overman or Deputy, and securely locked.

2. Should any accident happen to the lamps whilst in use, by which either the oil is spilt upon the gauze, or the lamps are in any other way rendered unsafe, they are to be immediately taken to the out-bye side of the Davy Door, and not again used until they have been properly examined by the Deputy or Lamp-keeper.

3. The hewers, or any person to whom a Davy Lamp is entrusted, are strictly prohibited from interfering in any way whatever with the lamp, beyond the necessary trimming of the wick.

4. Should any hewer, putter, or any person whatever,

who is in charge of a Davy Lamp, in any case lose his light, he is to take it himself to the out-bye side of the Davy Door to be re-lighted, and is not allowed to send it out by another person.

5. It is particularly requested that any person witnessing any improper treatment of the Davy Lamp by the boys or others, will give immediate information to the Overman in charge of the pit, that proper steps may be taken to guard the lives of the people employed in the mine.

6. Smoking Tobacco is not allowed in any part of the mine where Davy Lamps are used; and persons found offending against this order are liable to a fine of ten shillings, or to be taken before a magistrate, at the option of the Owners or Viewer. The fine to be paid to the informer.

7. No candle to be taken nearer the broken flat than the station fixed by the Overman; any one found with a candle within that distance, to be fined ten shillings. The fine to be paid to the informer.

8. No boys putting, as headsmen or double-trams, way-cleaners, or others, are under any pretext whatever to carry a lamp during the work. A sufficient number of lamps will be hung along the travelling-roads to prevent the necessity of these boys carrying lamps.

EDWARD POTTER,

VIEWER.

South Hetton Colliery, October, 1844.

CHAPTER XVII.

Scientific Instruments useful in Mining.

The Barometer, Thermometer, and Anemometer are only used in mines to a limited extent, notwithstanding that the Barometer may be considered almost indispensable in fiery mines having extensive goaves.

Gas, which accumulates in the goaves, in crevices of the mine, and in unventilated workings having no natural drainage into the air-courses, is liberated in bodies by atmospheric changes.

The Barometer, Sympiesometer, and Aneroid are used to indicate changes of pressure in the atmosphere; but the Barometer is most commonly used for this purpose. I would recommend the common Barometer, and not the Wheel Barometer.

A sudden fall of mercury in the tube of the Barometer, caused by a reduction of the pressure of the atmosphere, will be followed by the liberation of bodies of gas into the air-courses, from those parts of the mine in which it has accumulated.

T. J. Woodhouse, Esq., Viewer, Overseal, Ashby-de-la-Zouch, marks the index of each Barometer in use at the collieries under his management with the words "Fire slow," "Fire moderate," "Fire heavy." This

shews the degree of danger to be apprehended in the mine by a sudden reduction of pressure to these points, after the Barometer has been high for some time. This mode of marking the index is objectionable, because it will not in all cases indicate the state of the mine, as the following instances shew:—

If the Barometer falls to "Fire slow," and remains at that point for a time, part of the gas will be liberated from the goaves by this reduction of pressure. If afterwards a further reduction of pressure in the atmosphere takes place, and the Barometer falls to "Fire heavy," the extent of danger will not be as indicated; the previous fall to "Fire slow" will be followed by the liberation of much of the gas, and the danger will be only in proportion to the amount of the reduced pressure.

Or, if the mercury in the tube of the Barometer falls to "Fire heavy" marked on the index, and stands at that point for a time, and afterwards rises to "Fire moderate," the mine will not be found in the state of danger indicated. The reduced pressure or density of the atmosphere, when the mercury falls to "Fire heavy," liberates a portion of the accumulated gas from the goaves into the air-courses, until its density, and that of the atmosphere are nearly the same; consequently, a rise of the Barometer to "Fire moderate," or an increased pressure of the atmosphere to raise the Barometer to that point, will force back the gas into the interior of the goaves, and will also stop the supply from blowers.

Thus, instead of the mine adjoining the goaves being in the state indicated by "Fire moderate," it will, under these circumstances, be clear of gas.

Danger is to be apprehended from accumulated gas in the goaves upon a sudden fall of the Barometer, after it has stood high some time, the extent of danger being in proportion to the fall.

With a rising Barometer, or increasing pressure of the atmosphere, the gas is driven into the goaves and crevices of the mine, and the supply becomes reduced from the blowers. The gas is then accumulating, and ready to be liberated into the workings when a reduction in the pressure of the atmosphere takes place.

When the Barometer is changeable in its movements, the ventilation and state of the mine require much attention to ensure safety.

If the index of the Barometer is marked with the words "Fire slow," "Fire moderate," "Fire heavy," the Underground Manager may depend too much upon these indications as to the state of the mine. I have already noticed that it will not, in all cases, if so marked, indicate the state of the mine.

To make Barometrical observations useful, they should be taken frequently and regularly, and noted in a book kept for that purpose; for it is only by comparing these observations, that the amount of danger, by atmospheric changes, can be ascertained.

Observations by the Barometer are not, however, of

any use in cases of sudden outbursts of gas, which are met with in some of the deeper seams, and rush into the mine as the workings approach the cavities in which the gas is lodged. Good ventilation, and the exclusive use of the safety lamp, must be resorted to in such mines.

The Thermometer indicates changes in the temperature of the atmosphere. An increase of the temperature reduces the ventilation of the mine, by making the temperature of the down-cast and up-cast shafts or pits nearer alike, the ventilating power of the furnace being dependent on the difference of temperature in these shafts. A reduction of pressure of the atmosphere, in connection with an increase of temperature, not only liberates gas from the goaves, and increases the supply from blowers, but the increased temperature reduces the ventilation; and thus, increased danger in the mine is accompanied with reduced means to remove it.

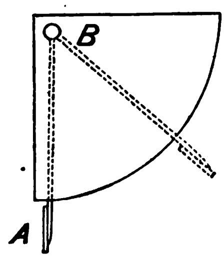
When the Instruments indicate a reduction of pressure, or an increase of temperature, immediate steps must be taken to increase the ventilation, the regulators must be opened on the districts of the mine requiring more air, and the dangerous returns passed into the up-cast shaft without coming into contact with fire. If the seam is ventilated by one body of air passing through the mine, the men should be withdrawn until danger is over.

Underground Managers must not depend too much upon Instrumental observations, and neglect to inspect the state of the mine: a daily and vigilant inspection

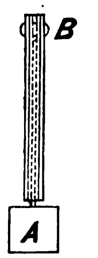
of every working part of the mine should accompany such observations.

The Anemometer is an instrument by which the velocity of the air is ascertained with sufficient accuracy for practical purposes. The velocity of the air multiplied by the area of the passage, at the point where the velocity is ascertained, will give the quantity of air passing along; thus, if the Anemometer indicates the velocity of the air to be 10 feet per second, and the area of the passage be 30 square feet, 300 cubic feet of air will pass along each second, or 18,000 cubic feet per minute. When it is ascertained with what velocity the air should pass through the regulator of any district, in order to keep such district in a state of safety, it may be inferred that a reduction of this velocity will diminish the safety of the mine. The velocity of the air may also be ascertained by noting the speed at which smoke from ignited powder will pass along a drift or passage of regular area.

The annexed Figures shew the side and end views of a simple instrument to be fixed either on the roof, or in some other convenient position in the air-way, for the purpose of indicating changes in the velocity of the air. Two quad-



SIDE VIEW



END VIEW

rants of wood or other material have a pendulum of metal, which will not be affected by the atmosphere, suspended, so as to swing freely between them from (B); attached to the bottom of the pendulum is a square plate (A) of copper or zinc. The current of air blowing on the plate (A) raises the pendulum, the different elevations of which will shew changes in the velocities of the air. This instrument, if properly adjusted, and graduated on the outer edge, may be made to shew the velocity of the air at the different points of elevation of the pendulum with sufficient accuracy. If not so adjusted, the velocity of the air might first be found by the Anemometer, and the rise or fall of the pendulum above or below the point noted on the outer edge of the quadrant, and to which the velocity elevates the pendulum, will indicate an increase or decrease of the velocity.

Or, a simple Anemometer, on the principle of Sir George Cawley's, may be used, by which the velocity of the air is ascertained from its pressure on a surface exposed to the current of air.

The Water Guage is an instrument sometimes used in mines to shew the strength or rarefying power of the furnace, or the force exerted in moving the air, and is applied to a hole in either a door or stopping separating the intake air from the return air, when, according to the force of the ventilation, will the water be elevated in the gauge. If the guage is applied on a short course

connecting the down-cast and up-cast shafts, an effective furnace will elevate the water in the guage from one to two inches, thus indicating a ventilating force of from 5 to 10 lbs. to the square foot, and producing velocities from 40 to above 60 feet per second in the up-cast; these velocities are, however, only attained by the air passing directly from the down-cast to the up-cast. This instrument is of no use for any other purposes connected with the ventilation; for, if when applied near the shaft it indicates an effective furnace, we are not to infer that the ventilation in the mine is good; because, an impediment to the ventilation, beyond the point of observation, would throw greater pressure on the partitions lying between the shaft and the impediment and separating the intake and return air-courses, thus elevating the water in the guage higher, and thereby denoting the agency of a more powerful furnace than if the ventilation were unobstructed. The old pit man soon detects any obstruction to the ventilation, by the increased whistling of the wind escaping through the doors and stoppings which separate the intake and return air-ways.

CHAPTER XVIII.

REMARKS ON FIRES IN COAL MINES.

FIRES in coal mines arise from various causes,—from explosions of gas, from underground engine flues, from the furnaces used for the ventilation of mines, from exposed lights left in mines, and from spontaneous combustion, in the goaves, of the refuse coal containing pyrites.

The means adopted for the extinguishing of a mine on fire, are either to exclude such part of the workings, as are on fire, from atmospheric air, or to fill the workings with water, or to pour water upon the fire through jets.

The process of excluding atmospheric air from the fire is frequently a dangerous proceeding, owing to the explosion of the gas which is distilled by the fire from the coal, and it is found in many cases impracticable to exclude it. The filling of the workings with water is attended with considerable cost, and only resorted to in extreme cases; it being an easy matter to run the water into the mine, but costly to pump it out. Water, moreover, destroys the roads, and injures the appearance of coal standing in pillars. In some cases, after the water has extinguished the fire, spontaneous combustion

takes place, probably through the damp state of such metals as contain pyrites.

Goldsworthy Gurney, Esq. (the inventor of the use of high-pressure steam for ventilating mines), suggested, two years ago, to a colliery owner in Lancashire, who had a mine on fire, the idea of extinguishing the fire by filling the workings with de-oxydized air, which was procured by passing atmospheric air through a fire, when it was conducted to a shaft and passed through the workings by means of a jet of steam, in both the down-cast and up-cast shafts. The experiment was successful; but the fire, having only recently originated, was burning on the surface of the coal, and there being no body of heated strata, it was merely flame that was extinguished. (For the particulars of this experiment, see Mr. Gurney's evidence before the Lords' Committee on the Ventilation of Coal Mines, 1849).

Some months ago, a portion of a Cannel Mine took fire from an underground engine flue, and had been burning slowly some time before it was discovered. The roof of the mine consisted of 6 inches in thickness of inferior cannel, and above this of from 6 to 8 inches in thickness of black shale mixed with pyrites. When the fire burst into flame, it spread rapidly along the roof in the bords. At this time I was called in to advise with the owners: the first step taken was to endeavour to subdue the fire with powerful jets of water, circum-

stances being favourable to this. As there were pumps in the shaft near the site of the fire, and the bottom lift was about 60 yards long, 4 inch pipes were connected with this lift, and laid down along the locality of the fire: taps were then fixed in the pipes at intervals, and made to couple with hose pipes, which were fitted up with jets. The Pumping Engine was then kept working, and supplied water at a pressure of about 80 lbs. on the square inch.

Before water was poured on the fire, pillars of cannel, and the roof of the mine for more than 30 yards along the levels, were on fire; and in some places the fire was so intense as to vitrify the measures above the cannel. Water was continued to be poured on the fire by several jets for three weeks, until there was no appearance of fire on the outskirts of the locality where it existed. This portion of the mine was then closed up, and remained so for some months. Shortly after it was re-opened, the fire again broke out, but not so extensively as at first. We then had recourse to Mr. Gurney's mode of extinguishing fire, and for that purpose constructed a portable apparatus to force the atmospheric air through a furnace. From this furnace, and before coming into contact with the fire, the de-oxydized air passed along 20 yards of tin pipes made 10 inches in diameter, and covered with a stream of cold water. The de-oxydized air was sent on the fire for three weeks, when that portion of the mine was again closed up.

Three months after it was thus closed, it was again re-opened, when little fire was visible, which was extinguished with water. Twelve months ago, a road was formed along the low outskirts of the fire by a brick archway, and although, as might be expected, there was considerable heat, the fire has not again broken out where the water was first poured on, but it made its appearance a considerable distance on the rise, but was subdued by a few applications of water from a jet.

Mr. Gurney has recently applied his plan to the extinguishing of a fire which has been burning for about thirty years in a mine near Alloa, in Scotland; and at the present time, according to a letter which has appeared in the London Times, it is believed that his efforts have been attended with complete success.

At Wallsend Colliery, a very fiery seam was worked some years ago, under the superintendence of the late Mr. Buddle, and the gas which oozed out at the pores of the seam was frequently ignited by the blasting of the coal; at times there was some difficulty in extinguishing the lighted gas by the usual method of *dusting* it out with wet sacks, when, at length, Mr. Buddle adopted the plan of extinguishing the fire by concussion of the air, which was effected by discharging a cannon in the direction of the burning gas. I have, in like manner, by concussion of the air, extinguished gas which was burning on the surface of the coal, when it was inaccessible to the use of other means.

CHAPTER XIX.

Advice and Practical Hints to Underground Colliery Managers.

Many of you may have commenced your career of labour in the Pit at an early age, and your opportunities for receiving instruction may have been few; yet by application and diligence you may have raised yourselves above your fellow labourers, and been selected for your intelligence by your employers, to watch over their interests in the management of the mine. Be persevering in your endeavours to add to your stock of knowledge, and thereby improve your general intelligence. Read practical and scientific publications which treat upon subjects connected with your employment; and, in selecting such works, endeavour to obtain the advice of a person who is able to judge of their merits.

That there are many persons who object to the idea of scientific knowledge being applied to aid the operations of the miner, notwithstanding that it has already done much for the advancement of mining, is simply to be deplored.

An eminent scientific man some years ago visited the Collieries in the North of England, with the object of ascertaining whether something could not be invented

to secure the light which the miner used, from exploding the gas met with in mines. The result of this Gentleman's visit, and subsequent investigations into the subject, was the invention of the "Davy or Safety Lamp," so well known to miners. Another eminent scientific man, after a visit to coal mines, first made known the principle of ventilation by means of the Furnace.

Practical men, combining scientific with practical knowledge, may yet accomplish greater improvements in mining, and lay down more effectual plans for protecting the lives of the employed, than have hitherto been brought to light. Many of the most eminent Engineers of the present day commenced their career in humble circumstances, and have by industry and perseverance raised themselves from the position of workmen to the high standing they have now attained.

Be temperate, consistent in your conduct, punctual in the discharge of your duties, and both by example and precept, encourage the men under your care to do the same, always bearing in mind that the workmen under your authority will, in most respects, conform their conduct to yours. Mildness, firmness, and decision, will ensure obedience to orders or instructions that you may give, rather than boisterous and indecisive conduct. In giving instructions about work, forbear mixing them up with foolish remarks, and speak in such a way that the men may see that you have your employers' interest at heart; and when you have issued your

orders, never allow the men to slight or neglect them.

It is the practice of some Underground Managers, when orders have to be given to the men, to send some subordinate person to issue such orders, although it may be important that the Underground Managers should attend personally to this part of their duty. It not unfrequently happens that an unwillingness to undertake the whole labour attendant upon their duties occasions the adoption of this plan. Men actuated by such feelings are not worthy of their office: whatever duties belong to your office faithfully discharge. If you send instructions through another, he may have an imperfect conception of your ideas, and may thus give such instructions very inaccurately: in addition to this, workmen, in many cases, slight the orders of a subordinate. The consequence of such neglect may be, that that which ought to have been well done may only be imperfectly executed, and may soon require to done again, at a greater expenditure than the first cost. I have known several fatal accidents arise through Underground Managers delegating their duties to others.

When work is required to be done connected with the mine, you should not neglect to inspect the place, previously to the work being commenced, and although you may afterwards learn from report that the work is progressing well, you should not rest satisfied with the report, but see and judge for yourselves whether it be properly executed. Workmen very soon perceive when

an Underground Manager is easy and indifferent in the execution of his duty, and soon imbibe the same feeling of indifference, neglecting his orders in his absence. Thus, instead of having men aiding him to carry on the work as it ought to be carried on, and in preserving good order and discipline in the mine, the contrary state of things exists, and the mine is continually in a state of disorder.

Acquaint yourselves with the workings of your mine, and endeavour to fix them in the mind, that every part may be so familiar to you as to render it unneccessary on all occasions to refer to a plan. This is a matter of great importance, and it is one that, if daily in the mine, you may soon acquire; such a knowledge will enable you to see what provisions may be necessary for the daily progress of the workings, and also for the carrying out effectively a good system of ventilation; it will further enable you to see whether any alterations that you may make in the mine will add to its safety or otherwise, besides enabling you more easily to discover causes of danger, and to ascertain in what way remedies should be applied. Without this knowledge of your workings, you will only discharge the duties of Underground Manager very imperfectly; you may have a Plan to refer to, but a knowledge of the workings, derived from reference to a Plan, is not to be compared with that intimate knowledge, which is gained by making your workings the object of daily thought and reflection.

Should you occupy a place under a Master or Viewer, who conducts the mine under good regulations, and an able system of management, it is, notwithstanding, necessary that you should have a knowledge of your workings, to enable you to carry into effect his instructions, and to exercise a wholesome supervision over the operations of the mine.

You should also possess a knowledge of dialling, so that you may lay out your workings systematically, and drive them with regularity.

The utmost attention should be paid to those arrangements of the mine, upon which the health and lives of your men depend, and the nature of the accidents, to which the mine is most liable, should be ascertained, in order that steps may be taken to prevent their recurrence. You will find, appended to this Work, rules and regulations pointing out the means which should be used to preserve the health and safety of your men.

When working near, or towards, old workings, drive exploring drifts, and keep borings in advance of the face of the drifts, so as to prevent the sudden outbursts into the mine of water or gas which may have accumulated in them. Use the safety lamp; and, if practicable, send the air, which has ventilated these drifts, to the up-cast shaft without passing the workmen, or going along any travelling-road in the mine, or being brought into contact with the furnace fire.

If your mine has any fire damp in it, never allow

inclined or level workings which end in the solid, to remain without ventilation, as gas will accumulate in such places, which, being open parts of the mine, become liable to explosions. If you have such places unventilated in your mine, and have occasion to go into them, use a safety lamp, and never follow the practice which some pursue, of leaving their candle at the bottom end, and going in without light, because the movement of the body may force out the gas, which will probably explode at the light. Your best course, however, is to ventilate such places. Unventilated places driven to the deep will have a natural drainage of fire damp, but upon which you must not depend to the neglect of the ventilation: if the fire damp drains from them, black or choke damp may accumulate there.

When you are working up to, or along the side of, troubles, dykes, or faults, keep your ventilation up to the face of such places, and use the safety lamp: fire damp is met with in great quantities in such parts of the mine, and, in the vicinity of these dislocations are found, in deep mines, cavities filled with compressed gas. If it is dangerous to work any part of your mine with naked lights, lose no time in supplying the men with safety lamps, which should only be employed under strict regulations.

Never descend unventilated old shafts, without first ascertaining their state with a safety lamp. Choke damp or carbonic acid gas, will accumulate in them, and many

accidents have happened through men imprudently descending such shafts. A few shovelsful of lime, slacked to powder, thrown into the shaft, will clear it of choke damp, a remedy I have adopted on several occasions with the desired effect. The lime has a strong affinity for the choke damp or carbonic acid gas, and readily absorbs it.

You will be aware that gas or fire damp, and black or choke damp, accumulate in the goaves or those parts of the mine where the coal is all got, also in crevices of the mine, and in unventilated parts of the workings. You will doubtless have observed more gas in your workings at one time than another, which gas has come from the goaves and other parts of the mine where it has accumulated; and also that blowers, which at one time give out gas, will, at another time, draw in air. A change in the weight or density of the atmosphere is the cause of this. When a change takes place from a less to a more dense atmosphere, the gas will be forced back into the goaves, and blowers will draw in air. When a reduction of the density takes place, the gas in the goaves expands, and is then liberated in considerable quantities into the workings, and the blowers also give off gas freely. In the absence of Instruments to indicate changes of pressure in the atmosphere, it would be desirable that you should observe the direction of the wind, as changes in the wind's course are accompanied by changes in the pressure of

the atmosphere. North-west, north, and north-east winds may be considered favourable, as the atmosphere is generally of greater density, and gas then accumulates in the goaves and crevices of the mine. As the wind passes southerly from north-west, and southerly from north-east, the density of the atmosphere decreases, and south-west, south, and south-east winds may be considered unfavourable, and gas is then liberated from the goaves and other parts of the mine. Changeable and high winds act unfavorably to the safety of mines, by impeding the ventilation.

In order to observe the course of the wind, fix the points of the compass in a conspicuous place on the colliery, with a moveable vane, and it will be advantageous to have it so arranged that you may see the course both by day and night. This you can effect by continuing the spindle of the vane down into a cabin, or other convenient place, and by erecting underneath a board having the points of the compass described upon it, and properly adjusted. When you observe unfavourable changes take place, the ventilation should be increased, and if the return air is highly charged with gas, it should be sent up the up-cast shaft without being brought into contact with the furnace; but in a well ventilated mine this will be unnecessary. If your mine is ventilated with the air passing through it in a single current, you should withdraw your men until it is safe.

A reduction in the pressure of the atmosphere not only increases the danger in the mine, by liberating, as has been before stated, bodies of gas from the goaves, but renders greater the liability to falls from the roof. A reduction of this pressure will operate in the same way as a removal of support will do from the roof of the mine, consequently the tendency of the roof to fall will be much greater when the pressure of the atmosphere is diminished.

The density or pressure of the atmosphere may be reduced by other causes, independently of any change of the wind; hence the necessity for observations by proper Instruments.

The use of scientific instruments, and their careful application, will give notice of those atmospheric changes which cause bodies of gas to be liberated from the goaves and crevices of mines. The Barometer and Thermometer are both valuable instruments in a colliery, the one, as before explained, indicating changes in the pressure of the atmosphere, and the other changes in the temperature. The Anemometer will furnish a tolerably correct idea of the quantity of air passing through any part of the mine. Having fully noticed the use of these instruments in a previous chapter, I need not enlarge upon their utility here.

The operation of undermining coal preparatory to blasting, or wedging, it from the bed, has various local terms, such as *kirving*, *bearing*, *holing*, &c., but although

the two last have been used in various parts of this Work, I propose here to adhere to the term *undermining*. Some men cut away a height of from 18 to 20 inches at the face, in order to undermine 36 inches; these men generally begin the operation on their feet, and from this position they strike the seam at the height of from 18 to 20 inches from the floor, and generally undermine nearly 2 feet before changing to a sitting posture in order to finish the undermining; in a place 4 yards wide, these men cut to waste or to small about a ton of the best part of the seam, in undermining a yard forward: other men begin the operation in a sitting posture and strike the coal low, and will undermine from 30 to 33 inches, and only cut away a height of 8 or 9 inches at the face. These men will send half a ton or thereabouts of round coal more, from each head or yard forward, than the other men who undermine high. It is true that the man, who stands when he begins to undermine, can give a heavier blow with the pick, because greater force is communicated by the swing or momentum of his body, than can be obtained in a sitting posture, the force being produced in the last posture by muscular exertion alone.

If pit men would only consider their own interest, they would see that the saving of labour to the man who undermines low is considerable, and that it would pay them well to adopt the practice; but in many cases touching their welfare, they are apt to evince a great

want of reflection. In addition to economizing their labour, they would send more large coal out, for which a greater price is paid than for small or slack, and would earn from two to three shillings per week more on their coal, with less labour than the high underminer would have to bestow for the same area of mine excavated. If the coal is sent out without separation or dressing, and the same price be paid for large as small, you should have regulations to compel the men to undermine a fixed length, and only cut away a given height, say 8 or 9 inches for 33 inches undermined, and you should allow such of the men, as adhere to the dimensions you give, a small additional price for getting the coal, and should inflict a fine on those who exceed these proportions. There are many men who will confine themselves to these proportions; it is not, however, the strongest or the most powerful who will do so, but the expert and skillful workman. What one man can perform by his skill as a labourer, others can also be trained to do. In addition to making the men undermine low, you should compel them to undermine a proper length, so as to give the coal a better chance of being either wedged down, or blasted with powder in a mass. Many men are too idle to undermine a proper distance, and get their coal in short heads, seldom sending any large coal out: such men will probably be found amongst your young men, whose work should be diligently inspected.

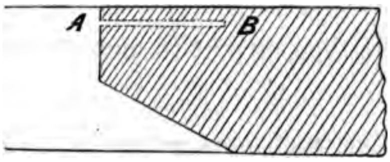
There will probably be many young men in your mine who may shortly become coal getters;—you may train the young more easily than you can correct the bad practices of the old, and if you neglect to adopt a proper course of training in regard to these young men, and they grow up indifferent workmen, you will incur a grave responsibility. No young man should be allowed to get coal unless he will undermine low.

The floor of the seam will, in some cases, be favourable to undermine in. A tender floor, or a floor mixed with bands of coal, may, under some circumstances, be undermined in, without cutting good coal to small. There are some objections to undermining in the floor of the seam, as it destroys the smooth surface, and makes a bad bottom to shovel upon, unless you have a hard even surface for the bottom of your undermining, which will then make a good surface to work upon. The screenings, or slack, from seams which are undermined in a bad floor, will be almost useless, owing to the quantity of thill or floor which is intermixed with it. If the coal is separated below, and the small be cast away, some portions of the floor will go with it, but much will come out with the coal. If the loss of the slack, and the increased cost of getting the coal by casting away the small, and undermining in the floor, is more than compensated for by the increased quantity of round coal, you may undermine below the coal when the floor is favourable and dry; but care should be

taken that you possess these advantages before you commence undermining in the floor.

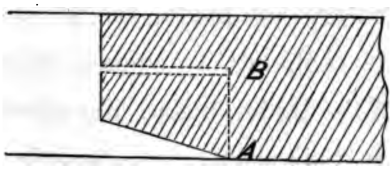
Another point to which I wish to direct your attention is the blasting of coal. This is generally done very injudiciously—too much powder is used for a shot, which impairs the cohesion of the coal; and, in many cases, the hole is not drilled in the proper part of the seam.

The hole for blasting is generally drilled near the roof (see Section 1), thus making the line of least resistance, in thick seams, to the effects of the powder in the direction of the hole (B A), and requiring a much larger charge of powder to sever the coal from the bed, than if the hole were in the most favourable position.



SECTION 1

In order to blast coal with less injury to its cohesion, the hole for receiving the powder should be in such a position, that the line of least resistance may be in the direction of the line (B A), or from the hole to the undermining (see Section 2), when a much smaller charge will be required to sever the coal from the bed. You should ascertain by experiments under your direction, the best position for the hole in the seams which



SECTION 2

require powder, and also the least quantity that will sever the coal from the bed in the largest pieces. Where the coal separates freely from the roof, the position of the hole, should be as shewn in Section 2; where the coal adheres to the roof, the position of the hole should be as shewn in Section 1. The quantity of powder required, and the position of the hole, should never be left to the pit man's judgment.

When you can dispense with powder in getting coal, do so by all means, and make more use of the hammer and wedge, as the coal will then be sent to market in a much better state.

You should take care that each coal getter is at all times provided with a full set of tools, whether it is the practice for the master or the pit man to find them; for, without a proper set, even a good workman cannot send his coal out in a good state.

I would here make a few remarks on the objectionable practice, in many collieries, of each collier providing labour to convey his coal to the horse-roads or shafts. When contracts of this nature are made, the youths employed in removing the coal, are, to some extent, freed from the authority of the Underground Managers, and look upon the collier as their master, who too often encourages them in acts of disobedience. If a collier cannot get as much coal in a day as a youth can remove, such a rate has to be paid for the coal as will make wages for both, and the youth's spare time is

frequently employed at the coal face, which he almost invariably cuts to small.

If the getting and conveying coal were separated, and each were paid for by the score, dozen, or ton, as the case might be, the coal would be conveyed at a less cost, as the youth's time would be entirely occupied with his own duties, and he would convey a greater quantity in a given time; he would, moreover, be under the control of the Underground Managers, and as opportunity offered, might be placed in those parts of the mine most favourable for training him as a pit man. Managers accustomed to the former practice, effecting this change, will shortly find their labour diminished, and that better order can be maintained in the mine.

It is customary at many collieries to determine by lot, every two or three months, in which part of the mine, each collier shall work; thus, all the pit men are placed on the same footing with regard to the choice of places, and the unpleasantness and jealousy which frequently exist amongst them, where it is the practice for the Underground Manager to decide where they shall work, are avoided.

On account of the numerous strikes which have taken place amongst pit men, and the rapid extension of mining operations during the last few years, many workmen ignorant of mining have been employed in mines, and to this circumstance may be attributed the great proportion of slovenly and incompetent pit men

now to be found in almost all collieries. Especial care should be bestowed upon these men in regard to instructing them in their duties, and informing them of the dangers incident to mining.

It is your duty to protect and promote your master's interest, and not to allow it to be sacrificed by the negligence or indifferent workmanship of those under your care. Never employ slovenly workmen, but select, if possible, good, steady, and intelligent men. I would particularly draw your attention to the small proportion of good pit men, or coal getters, to be met with in almost all collieries, and I would urge you to use your best exertions in improving the standard of labour among your pit men. Much will depend on your diligence in this respect. By good pit men, I mean those who undermine the coal low, and send to bank as great a proportion of large or round coal as the seam will yield, and attend regularly to their work.

I am aware that you will meet with much opposition from pit men, in endeavouring to carry these recommendations into effect, because they generally take erroneous views of things which interfere with their labour, or cause an alteration in the state of things to which they have been long accustomed. In all cases I would advise you to be guided rather by your own opinion as to what is necessary to be enforced, than to be influenced by the inconsiderate ideas of the men in your employ.

CHAPTER XX.

Rules and Regulations to be observed by the Workmen at ——— Colliery.

It is impossible, within reasonable limits, to frame Rules for the working and discipline of a mine, that may be applicable to all collieries, as there will be circumstances connected with some collieries requiring special rules. The following are rules that I have had in force at a fiery colliery, a great proportion of which are inapplicable to a mine producing no gas:—

Rules for Surface Labourers.

The Banksman must be in attendance every morning during the descent of the workmen, and remain at his post until the last man is out of the pit at night. Before any person descends in the morning, the ropes must be run up and down in the shafts, and carefully examined by the Banksman, from the cages to the ends fastened on the drums or verticles. The Banksman must also daily examine the cages, chains, pulleys, and other machinery about the pit top, and if he discover any flaw or breakage, he must see that it be repaired before any person is allowed to descend. The Banksman must also keep an account of the name of each workman who

will be fined ——, or be immediately discharged.

Before any person descends or ascends any of the shafts, the proper signal must be given; and all signals from the shafts must be given in the Engine-house near the Engineman, by apparatus for that purpose, in order that the necessity for the Banksman to call to the Engineman may be avoided; and any workman descending or ascending, or any Banksman or Hanger-on allowing any workman to descend or ascend, when the pit is at work, without the usual signal being given, will be fined.

Not more than —— persons must descend or ascend the shafts at once, nor against tubs full or empty in the cage; and any person acting contrarily to these orders will be fined ——.

The Viewer or Underground Manager will determine in which part of the mine safety lamps must be used. Any person using a naked light, where safety lamps have been ordered to be used, or found with his lamp top off, or leaving a light in the mine, will be fined ——, or be taken before the Magistrates for the offence.

The stoppings, crossings, and doors, must be daily examined, and all bratticing kept in good repair, and be not less than seven feet back from the face of the place; and all air-doors to direct the ventilation must be so hung that they will shut of themselves. Any person interfering with any air-door, except passing through it, or attempting to derange the ventilation in any way,

will be taken before the Magistrates for the offence, or be fined ——.

The air-courses, and the state of the return air, must be examined daily, and if the return is found highly charged with fire damp, it must be sent into the upcast without passing over the furnace, or, if sent over the furnace, it must be diluted with a scale of fresh air.

The openings in the main-roads must be made good with stoppings, one brick in length, set in lime; and, when practicable, in addition to the brick stopping, the openings must be packed solid with stone or other material, so as to resist a blast in case of an explosion.

Sufficient timber must be set to support the roof in every working part of the mine, and no props must be drawn in the pillar workings without a safety lamp. Particular attention must be paid to the state of the roof, and its temporary supports, when any considerable reduction takes place in the pressure of the atmosphere, as there is greater liability in the roof to fall at such a time.

When working the pillars, large falls of roof must be carefully watched, particularly the first falls which take place after the pillars are commenced working, and also the falls in the banks of long work, for both of which preparation must be made by an increased circulation of air, and by securing the working face with timber or other supports. In mines producing gas, large quantities are generally forced from the goaf. The workmen are desired, in all cases, immediately to

inform the Underground Manager, or the person in authority under him, of any danger that they may observe in the mine.

The Underground Manager, and those in authority under him, must bear in mind that atmospheric changes influence the discharge of bodies of gas from the goaf. The Barometer indicates these changes in the atmosphere. In the absence of a Barometer they should observe, daily, the point from which the wind blows, as changes take place in the atmosphere with changes in the wind. (For particulars on this subject, see Chapters 17 and 19.)

Any person found smoking in the mine, will be fined ——, or be taken before the Magistrates for the offence; and any person found with lucifer matches or a pipe in his possession, will be fined ——.

The Colliers must work the coal to the best advantage, and send as large a proportion of round or large coal as the seam will yield, and the coal must, in all cases, be sent out clean from slates and stones, and well riddled. Any tub containing —— of stone or other refuse, or not being well riddled, or being sent to bank short measure, will be deducted from the workman's wages, if such tub is sent out after notice has been given; and any tub of round, sent to bank reared or set, will be deducted without notice. The workmen must get the different seams according to the directions and dimensions given by the Viewer, or Under-

ground Manager, and if the workmen do not conform to the directions given, they will have to make good all damage arising from the neglect or disobedience of orders. No wages will be considered due until such damage is either repaired or paid for.

Any Collier, after he has descended the pit, not working a full day's work, nor sending out such a quantity as may be considered a fair day's work of —— hours in the seam in which he works, will be fined ——; and any Putter doing the same will be fined ——. No fine will however be imposed in case of sickness or other excusable circumstances.

No ale or intoxicating drink is allowed to be brought on the colliery, or taken down the pits, except in cases of necessity, and then only by the order of the Manager. Any workman infringing this rule will be liable to be discharged.

One month's notice shall be given or received by each Underground Workman before leaving his employment, or before any alteration is made in the rate of wages; and after such notice is given, no wages shall be considered due until the time specified in the notice has expired.

Rules for the Safety Lamp.

No Safety Lamp is to be used without having been first *examined, cleaned, passed as safe, and locked,* by a competent person on the colliery.

If an accident happen to a lamp, or the oil is spilt on the gauze, or the lamp is rendered in any way unsafe, the workman must put out the light by drawing the wick down within the tube with the pricker, and on no account must he blow the light out. He must then carry the lamp to the Lamp Inspector to be exchanged.

Any workman observing the indications of fire damp by the lamp, must carefully move the lamp, and with the pricker pull down the wick within the tube. He must then withdraw from that part of the mine, and give information to the person in authority in the mine.

Any person acting contrarily to these orders, or in any way attempting to damage a Safety Lamp, will be fined ——, or be taken before the Magistrates for the offence.

Any person observing any improper treatment of the lamp, is desired to inform the Underground Manager or Lamp Inspector; and any one giving such information will be rewarded.

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